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Operation and Management of Milk Plants[1]

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INTRODUCTION

Milk plants are established primarily for the purpose of buying milk from individual farmers or groups of farmers and preparing it for sale and delivery as pasteurized fluid milk or cream to consumers. Successful operation and management of the business depends not only on the executive ability and technical knowledge of the manager,

[1] This is a revision of a previous edition written by C. E. Clement, market-milk specialist of the Bureau of Dairy Industry, who resigned August 9, 1943.

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but also on the arrangement and equipment of the plant and on the efficiency with which various operations are performed.

Information about the construction, arrangement, and equipment of milk plants appears in other publications issued by the Department of Agriculture (*4*, *6*).[2] This circular gives basic information on the methods of operating milk plants which have proved to be satisfactory in practice, and discusses certain phases of management which are directly related to successful operation.

SYSTEMS OF BUYING MILK

In the early days of milk plant operation, practically all milk was bought on the basis of measure, that is, by the can or gallon. Milk buyers or distributors as well as producers recognized the inaccuracies of this system and the resulting unfairness both to the distributor and to the producer. Buying by measure has now been largely abandoned in favor of other systems that are more nearly equitable and at the same time more practicable.

Buying Milk by Weight

It is now generally recognized that weighing the milk when it arrives at the plant provides a more accurate means of determining the actual quantity received than measuring it by the can or gallon.

In a study by this bureau of the shipments of milk into one city, comparison was made of the quantity of milk received as determined by measure and as determined by weight. Observations were made on a total of 346 shipments of milk, consisting of 1,102 cans. The cans were examined on arrival at the plants, and the quantity of milk in cans that were not full was estimated by means of measuring sticks, so that an accurate check of the quantity of milk received as determined by measure was made before the milk was emptied into the weigh cans. The difference between the quantity of milk received as determined by volume measurement and the actual quantity received as shown by the scales, for the 346 shipments, was as follows:

Cans received—number	1,102.00
Milk received as determined by can measure—gallons	6,185.32
Milk received as shown by scales—pounds	52,191.00
Actual milk received as determined by weight (at 8.6 pounds per gallon)—gallons	6,068.72
Shortage as indicated by weight—do	116.60
Percentage of shortage	1.88

Thus the difference for the total quantity of milk received was 116.60 gallons, or 1.88 percent. The inaccuracies of measuring by volume or number of cans received were to a large extent due to poor cans, many of which were dented and battered.

Inaccuracies in determining the quantity of milk received that result from measuring by cans are due principally to the following causes: The cans are not filled completely by the producers; milk is spilled or leaks in transit; and cans which do not hold the specified quantity, because of dents or other defects, are used.

[2] Italic numbers in parentheses refer to Literature Cited, p. 58.

Buying Milk on the Butterfat Basis

Practically all milk is now weighed as it arrives at the milk plant and is paid for on the basis of the butterfat test, which has come to be considered the most important single factor in determining the price to be paid for the milk.

The most common method of fixing prices according to the butterfat test is to quote a certain price for 100 pounds of milk having a certain percentage of butterfat. To this base price for 100 pounds of milk, a certain amount is added for each additional 0.1 percent (or "point") of butterfat in the milk, or a like amount is deducted for each point that the milk falls below the basic test. For example, if the price is $3.80 per 100 pounds of milk testing 3.5 percent butterfat, with an allowance of 5 cents for each point above or below this butterfat content, the price for 100 pounds of 4-percent milk would be $3.80+(5 points×5 cents), or $4.05, while the price for 100 pounds of 3-percent milk would be $3.80−(5 points×5 cents), or $3.55.

In some sections milk plants quote a price of so much per pound of butterfat for milk containing up to a certain percentage of butterfat; and an additional sum, which is usually relatively less than the base price per pound of butterfat, is allowed for each pound of butterfat above the basic percentage that the milk contains. For example, the price may be quoted as 95 cents per pound of butterfat for milk containing up to 4 percent of butterfat (that is, 4 pounds of butterfat per 100 pounds of milk) with an additional 70 cents for each pound of butterfat in the milk above the 4-percent base. Thus the price for 100 pounds of milk testing 4 percent butterfat would be 4×$0.95, or $3.80, and for 100 pounds of milk testing 4.5 percent butterfat the price would be $3.80+(0.5×$0.70), or $4.15.

There is no standard system of quoting prices on the butterfat basis. In some markets the price may be based on milk testing 3.5 percent butterfat and in others on milk testing 3.8 or 4 percent. The difference allowed or deducted per 100 pounds of milk for each 0.1 percent (or point) of butterfat above or below the basic percentage will also vary from 3 to about 15 cents in different localities. In general, it may be said that the basic test agreed on between the distributor and producers should be as near as possible to the test of the milk put out by the distributor, and the differential added or deducted should be as near as possible to the value of butterfat in the form of sweet cream or butter. If the differential is set much below this point, it will tend to encourage the producer to cull his high-testing cows, or even to separate out some of the fat from the milk. On the other hand, if the differential is set much above the market value of butterfat in the form of cream or butter, the milk distributor would lose money on high-test milk, as he would not be able to dispose of the extra butterfat except in the form of cream or butter. Usually all milk received by the distributor, except special milks, is mixed in the plant, and the product put out is standardized to a uniform butterfat content and is sold by the distributor at one price. Therefore, he cannot afford to pay a higher differential for the extra butterfat, above this standard test, than it would be worth to him in sweet cream or butter. Furthermore, if the differential is set too high, it might

cause some producers to separate some of their milk and add cream to the whole milk. This would result in milk deficient in solids-not-fat.

Buying Milk on a Quality Basis

High quality milk should command a higher price than poor quality milk. Where milk is bought on a quality basis, special grades are usually established and premiums are paid for milk of extra grade. The factors most commonly considered in determining quality are the bacterial count of the milk, the dairy-barn score, and the health of the cattle. Other factors used in determining quality are the amount of sediment, degree of acidity, flavor and odor, and temperature of the milk when delivered to the plant.

Milk-Buying Plans Designed to Regulate Milk Production

While milk consumption will vary somewhat from day to day and from week to week, these variations are not great and the consumption of milk throughout the year tends to be relatively stable and uniform.

On the other hand, milk production is much greater in early spring than in late fall. During the latter period, when production is the lowest, the distributor must receive from his producers enough milk to supply his regular trade and take care of any increase in consumption. As he must carry these same producers throughout the year, he will receive a considerable amount of surplus milk during the spring when production is highest. Various buying plans designed to make production coincide as far as possible with market demands are in use. In general, three main plans of this type have been adopted in different sections of the country. These are: (1) The basic-surplus price plan; (2) the classification or use price plan; (3) the combination price plan.

There are many modifications of these three general plans.

THE BASIC-SURPLUS PRICE PLAN

Under the basic-surplus price plan the milk producer is compensated for producing a uniform volume of milk throughout the year. A basic quantity is established by each producer, for which the distributor pays the class 1 or market-milk price. For all milk produced above his basic quantity, the producer receives a lower or "surplus" price. Usually the fall months, as October, November, and December, are used as the base period during which the producer establishes his basic production. These are the months when production tends to coincide most nearly with consumption. Sometimes the production for the previous fall months is used as the basic production, whereas in other cases the average production for these three months over a period of years may be used. In some localities the producer is allowed to determine his basic quantity by contracting to deliver a definite quantity for the year. The price for class 1, or market milk, is determined in advance at meetings of representatives of the distributors and of the producers, and this price depends on such factors as market demands, business conditions, cost of production, etc. The price for surplus milk is usually based on its value for use in milk products. Under this plan the producer is given an incentive to produce a uniform quantity of milk throughout the year.

THE CLASSIFICATION OR USE PRICE PLAN

The plan of basing a price classification on use of the milk recognizes the fact that milk in different forms has different values and the prices paid under this plan vary according to the use that is made of the milk. The quantity of milk going into the various classes is determined from the records of the distributors, showing the uses to which the milk was put. In some cases, provision is made for at least four classes of milk, each being paid for at a different price, as for example, class 1, all milk sold in fluid form; class 2, milk made into cream that is sold in fluid form; class 3, milk made into manufactured products, except butter; and class 4, milk used in the manufacture of butter. In some instances all milk not sold in fluid form is used in the form of cream. In that case only two classes are required. In other instances all milk sold in fluid form and all milk made into cream that is sold in fluid form is included in class 1. The price established for class 1 milk is usually based on market conditions, such as probable total production in relation to demand for milk in fluid form. Prices for other classes are usually based on market quotations for cream, butter, cheese, and other products.

THE COMBINATION PLAN

In some localities the principal features of the basic-surplus price plan and the classification or use price plan have been combined into one plan. Usually where this combination plan is used, the milk is sold to the distributors by the producers' association in accordance with the classification or use plan, and the returns to the individual producers are made in accordance with the uniformity of their production; that is, the distributors pay the association for the milk according to the uses they make of it, as under the classification or use price plan, and the association pays the individual producers according to the basic-surplus plan, each producer being assigned a basic production for which he receives class 1 prices. Thus, the producer is given an incentive to coordinate his production with market demands and the distributor pays for the milk he receives according to the uses he makes of it. Under this plan the sums withheld from those producers who produce a varying quantity of milk throughout the year are usually put into an adjustment fund, from which compensations are paid to those producers whose production is more uniform. There are a number of modifications of this plan.

RECEIVING MILK AT THE PASTEURIZING PLANT

The milk as received from producers, directly or through country receiving and cooling plants, is usually brought to the pasteurizing plant in cans by motor truck, either from the railroad station or directly from the country. The trucks are unloaded at the receiving platform, the milk is graded and dumped, and the cans are washed and returned to the trucks, to go back to the producers and be filled again with milk. Much milk is also received in tank cars and tank trucks, especially at large plants.

All milk should be received at the plant in the morning, if possible. It is usually desirable to have all of the day's supply in before noon,

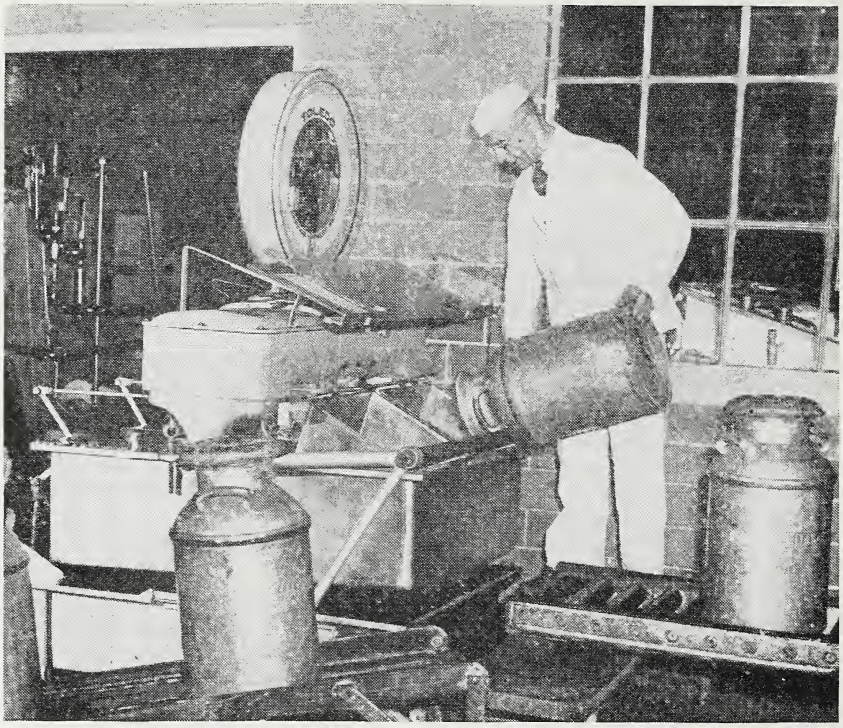

FIGURE 1.—Receiving milk at a pasteurizing plant.

so that none of the milk will be hauled in the heat of the day and the work of receiving it at the plant can be completed in good time.

The milk-plant manager is responsible for the quality of the milk put out at the plant, and he should require that milk be properly cared for at the farm where it is produced. The advantages of keeping milk clean and sweet should be pointed out. One of the most important points is keeping the milk cool. Producers should be instructed to begin early in the spring to cool the milk properly. Usually more sour milk is received at the plant in the spring and fall than during the summer, because many producers fail to realize the importance of cooling during the spring and fall.

GRADING, SAMPLING, AND TESTING

The milk should be dumped and weighed as soon as it arrives at the plant (fig. 1). Each can must be examined to determine the condition of the milk. This may be done by smelling or tasting, and any milk with objectionable flavor or odor should be rejected. Experienced men can usually detect off-flavored milk by smell.

After the milk is dumped into the weigh can and thoroughly mixed, a sample should be taken for the butterfat test (fig. 2). At plants where the milk is weighed in the cans, the sample is taken

directly from the can and in that case care must be taken to mix the milk in the can thoroughly before taking the sample. Except for very small plants, however, a weigh can is desirable, because it makes it possible for all the milk of each producer to be thoroughly mixed in the weigh can and a representative sample taken. Many plants also determine the acidity as a check on the condition of the milk when it comes in. Information on testing milk and cream is given in a publication on that subject issued by the Department of Agriculture (*10*).

In order to determine the bacterial content of the milk as it is received, samples should be taken periodically for bacterial analysis. Either a plate count or a methylene-blue test may be made. The methylene-blue test is simple and easily made. It is only an indicator, however, of the amount of bacterial activity in the milk under definitely prescribed conditions and should not be expected to correlate closely with the plate count. Most large plants have their own laboratories for making the plate count, but in small plants it is usually necessary to have this done by a commercial laboratory or the local health department.

FIGURE 2.—Testing milk for butterfat content.

Receiving Milk From Tank Cars and Tank Trucks

During recent years increasingly greater quantities of milk have been transported to the city in tank trucks and tank cars. In a report on the effects of milk-plant arrangement and methods of operation on labor requirements (7) it was shown that in plants where milk is received in tanks and there are no cans used for incoming milk to be washed, the whole process of receiving the milk is greatly simplified. Milk received in bulk can be unloaded much more quickly and with fewer men than that received in cans. This is illustrated in table 1.

Table 1.—*Results obtained from 2 methods of receiving milk at 115 plants*

Method	Plants	Milk received daily per plant	Help employed per plant		
			Men	Time required	
	Number	*Gallons*	*Number*	*Hours*	*Man-hours*
In cans from trucks	91	7, 328	3. 9	4. 6	19. 1
From tank trucks or tank cars	24	8, 102	1. 5	4. 4	6. 2

Method	Milk received per—		Time required to receive 100 gallons		Milk weighed at plant	Plants weighing milk
	Hour	Man-hour				
	Gallons [1]	*Gallons* [1]	*Minutes* [1]	*Minutes* [2]	*Percent*	*Percent*
In cans from trucks	1, 565	384	3. 8	5. 7	63. 8	64. 8
From tank trucks or tank cars	1, 834	1, 309	3. 3	3. 7	38. 8	33. 3

[1] Weighted average.
[2] Average of averages.

Where cans are used, each one must be unloaded from the truck, dumped into the weigh can, and the can washed. Where tank trucks or tank cars are used, the milk is transferred from the tanks to the weigh can or receiving tank by gravity, pump, or air pressure, and no handling of cans is required. Washing the tank in which the milk is received is a comparatively small task.

Other advantages of transporting milk in bulk are that usually it arrives at the plant in better condition, with a rise of only 1° or 2° in temperature and in some cases is fresher than if cans are used. Less floor space is also required at the plant.

The principal precautions to take in handling milk in tank cars and trucks are to set the tank car or truck so that it will drain empty, wash the valve connection before attaching the milk line, avoid con-

taminating the milk in operating the stirrer or in drawing samples, and to see that the tank as well as the plant-connecting lines, after being emptied, are thoroughly cleaned and treated to kill bacteria. It is essential to check the contents of tanks by weighing in the milk at the plant.

FILTERING OR CLARIFYING MILK

Milk is usually filtered or clarified at the milk plant to remove any foreign matter or small particles of dirt that may be present.

At very small plants, fairly satisfactory results may be obtained with a home-made filter consisting of filter cloth or of layers of cotton and cheesecloth. The milk passes through the filter as it is dumped into the weigh can (if one is used) or dump tank, or the filter may be placed at the entrance to the receiving tank. At large plants, special enclosed filters are generally used.

To maintain the filter in efficient operating condition without frequently shutting down to change the filter cloth, it is a good practice to install at least two filter units in the line with bypass connections. In such installations only one filter unit is used at a time. When the cloth is to be changed, the used filter can be bypassed and the valve to the other filter opened. This arrangement encourages changing the cloth at frequent intervals, thereby improving the functioning of the filter and assuring more dependable results. The cloths should be used only once. Filters are designed to filter cold milk. The temperature of filtering, therefore, may range from that of the raw milk as it is received at the plant to the pasteurizing temperature. The temperature most frequently used is approximately 100° F. Milk should be filtered before it is pasteurized, never after. Some boards of health require that the milk either be filtered cold or clarified.

A clarifier, which removes foreign particles by centrifugal force (*6*), is more efficient for this purpose than a filter. The sanitary superiority of the centrifugal clarifier as compared with other systems of removing sediment is obvious. The milk does not pass through an increasing accumulation of sediment, as it does in the case of a filter or strainer. The cost of a clarifier, however, prohibits its use in very small plants. Some operators place the clarifier in the system so that it replaces one milk pump, thereby reducing the initial cost of the plant equipment.

Formerly milk was preheated to about 85° to 95° F. before clarifying it, mainly because less foam results in this temperature range than at higher or lower temperatures. With the improved clarifiers milk may be clarified cold or hot, depending on where the clarifier is located in the system. The milk may be clarified as it arrives at the plant, then cooled and placed in storage tanks; or the clarifier may be placed between the storage tanks and the pasteurizer, or it may be placed between the preheater and the pasteurizer. Clarifying the milk cold eliminates the extraneous material before it is broken down or dissolved, thus preventing its off-flavors from becoming established in the milk by the application of heat.

Milk should be clarified before it is pasteurized, never after. Where the high-temperature, short-time system of pasteurization is used, the

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milk is either clarified cold (approximately 50°) before it enters the pasteurizing system, or it is taken from the regenerative section of the system and clarified hot (approximately 138°). The temperature of the milk apparently does not affect the efficiency of the clarifier. The same quantity of foreign matter is removed from the milk when it is clarified cold as when it is clarified hot. When the milk is clarified hot, however, the clarifier removes more casein products from the milk; hence the bowl fills up more rapidly than when cold milk is clarified. Frequently a clarifier will not run more than about 4 hours on hot milk whereas it will run 8 or 9 hours on cold milk. This fact frequently necessitates either shutting down to clean the clarifier or using two clarifiers instead of one.

HOMOGENIZING MILK

Homogenization of milk is a mechanical process whereby the fat globules are broken up to such an extent that they do not rise to the surface of the milk and form a cream layer. The proportion of market milk that is homogenized is increasing. It is reported by many investigators to be of a better flavor than unhomogenized milk (*2*). To have a satisfactory homogenized milk, the break-up of the fat globules should be such that after 48 hours' storage no visible cream separation occurs on the milk and the fat percentage of the top 100 ml. of milk in a quart bottle (or of proportionate volumes in containers of other sizes) does not differ by more than 10 percent of itself from the fat percentage of the remaining milk as determined after thorough mixing.

Homogenization causes the development of rancidity in raw milk and for that reason milk must be homogenized either immediately before it is pasteurized or immediately after it is pasteurized. Where the milk is pasteurized by the holder system, best results are obtained by homogenizing at or slightly above the temperature of pasteurization. Where the high-temperature, short-time system of pasteurization is used, the milk is usually homogenized as it leaves the regenerative section at a temperature of 138° to 140° F. From a sanitary standpoint milk should be homogenized before it is pasteurized, and some health departments do not permit milk to be homogenized after it is pasteurized. Those anticipating the preparation and sale of homogenized milk should, therefore, consult the health department of the community in which they expect to sell the milk.

The leucocytes in homogenized milk settle to the bottom of the bottle and frequently form a ring of sediment. These leucocytes cannot be removed by filtering the milk. However, they are removed by clarification, and a clarifier is practically essential, therefore, in the preparation of homogenized milk (*2*). Homogenized milk is less subject to oxidation but more subject to the action of sunlight than unhomogenized milk, and precautions should be taken to protect it from light (*3*).

PASTEURIZING MILK

Pasteurization is the process of subjecting every particle of milk to a temperature of not less than 143° F. for 30 minutes, or to not less than 160° for not less than 15 seconds, and immediately cooling it to 50° or below. In order to insure that all the milk will be heated to the re-

quired temperature, it may be necessary in some plants to operate the pasteurizer at a slightly higher temperature as a factor of safety. Whether this will be necessary depends somewhat on the heating efficiency of the pasteurizer, the accuracy of its temperature control, and the care with which it is operated. In order that the milk may be made absolutely safe for human consumption, it is essential that every particle be heated to at least 143° and held at that temperature for 30 minutes, or at least 160° and held at that temperature for at least 15 seconds. Proper pasteurization of milk not only kills all disease-producing bacteria that may be present, but also kills some of the lactic acid-producing bacteria and thus enhances the keeping quality of the milk (*1*).

While it is absolutely essential that the milk be heated to the pasteurizing temperature and held there for the required time, care must be taken that it is not heated too high. If the temperature of the milk is allowed to go much above the pasteurizing temperature, the cream layer may be injured. Experiments have shown that milk may be heated at 143° for 30 minutes with practically no injury to the cream layer. Heating milk at 145° to 146° for 30 minutes will cause a decrease in cream volume of approximately 8 percent, and heating at 148° for 30 minutes will result in an even greater decrease.

The proper pasteurization of milk is a simple operation and there is little excuse for poor results. Poor results are usually not the fault of the type of pasteurizer used but of faulty operation.

Ten causes of poor pasteurizing results are:

(1) Leaky or inaccurate valves, which allow some of the milk to get through the apparatus without being held long enough.
(2) Inaccurate temperature recorder; inaccurate indicating thermometer.
(3) Pipes and pumps not properly cleaned and treated to kill bacteria.
(4) Filler and valves not properly cleaned and treated to kill bacteria.
(5) Pumps and piping not of sanitary construction.
(6) Rushing milk through the apparatus too fast.
(7) Not heating milk to high enough temperature or holding it long enough.
(8) Adding raw milk to pasteurized milk in vat before the pasteurized lot is all drawn out.
(9) Formation of foam in the holder.
(10) "Pockets" in the apparatus which prevent some of the milk from receiving the required heat treatment.

OPERATION OF THE PASTEURIZING AND COOLING EQUIPMENT

Batch Pasteurization and Cooling

Batch pasteurizers are usually manually operated insofar as the holding time is concerned, and it is therefore important that a competent man be assigned to the work.

In filling the pasteurizer at very small plants, the milk may be poured directly into the pasteurizer from the cans if an efficient strainer is used. It is better practice, however, to pump the milk from a receiving vat or dump tank through an effective strainer or filter to the pasteurizer—a gravity flow may be used if the plant is suited to a gravity system. Great care should be taken to flow or pour the milk smoothly into the pasteurizer, as excessive splashing will cause foam, which is very undesirable.

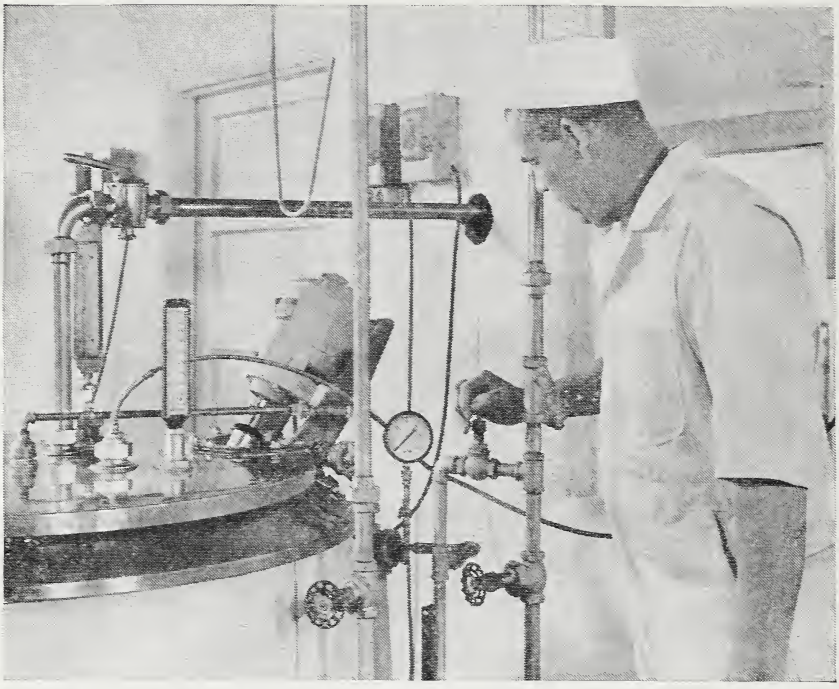

FIGURE 3.—Batch pasteurizer in which temperature is manually controlled.

The agitator may be started and the circulation of the heating medium begun before the pasteurizer is full. The temperature of the milk should not be allowed to rise more than slightly above the pasteurizing temperature. A higher temperature may injure the cream line, cause "cooking" of milk on the walls of the pasteurizer, and impart a scorched flavor to the milk.

During the process of heating and holding, the cover of the pasteurizer should remain tightly closed. Foam that may be present on milk in the pasteurizer and splash on the surfaces of the pasteurizer above the milk during pasteurization is frequently improperly pasteurized. Means should be provided and used, therefore, to maintain the atmosphere above the milk at a temperature at least 5° F. higher than the existing milk temperature during the heating period and at least 5° higher than the pasteurization temperature during the holding period. The pasteurizer should also be equipped with an automatic device that will shut off the circulation of the heating medium as soon as the milk reaches the desired temperature and that will automatically start its circulation during the holding period if the milk falls below the pasteurizing temperature.

In some of the smaller plants the temperature is manually controlled (fig. 3). In such instances when the dial on the temperature recorder indicates that the milk has reached the desired temperature, the circulation of the heating medium should be shut off promptly. The exact temperature at which circulation should be shut off to avoid overheating the milk depends on the individual plant, but usually the circulation should be stopped just before the milk reaches the pasteurizing

temperature. The operator, after a little experience, will learn to shut off the circulation at exactly the proper temperature. The agitator should continue in use until the temperature of the milk has become uniform in all parts of the pasteurizer. This condition may best be determined by indicating thermometers inserted at different points in the pasteurizer to supplement the recording thermometer.

If the indicating thermometers show that the milk has not been heated enough, circulation of the heating medium should of course be started again, but this rarely happens under an experienced operator. When all the milk is at the pasteurizing temperature, the agitator may be stopped and may be kept shut down during the holding period. Some operators, however, to insure complete mixing of the milk and a uniform temperature, start the agitator again before the end of the holding period. Moderate agitation during the holding period seems to have no appreciable effect on the cream volume of the milk.

The outlet valve should be of a close-coupled design so that no cold pockets of milk may be held in the outlet valve or pipe line. It should not be opened until 30 minutes after the milk reaches the pasteurizing temperature, and no milk should be added to that in the pasteurizer during this period. Preferably the pasteurizer should be emptied in from 15 to 20 minutes after the end of the holding period if the milk is sent direct to the cooler, or cold water may be introduced in place of the heating medium and the milk precooled to a temperature of 115° to 120° F. before it is released to the cooler. Cooling in the pasteurizer to a temperature below 115° is not desirble, as it may injure the cream layer of the milk. Precooling in the pasteurizer may lessen the work of cleaning it afterwards, as there is less likelihood of milk cooking on its walls than when the hot milk is not precooled. After the holding period the milk should, however, be cooled quickly to 50° or below, with as little agitation as possible. In order to prevent the milk from freezing on the coils of the cooler, the temperature and flow of the final cooling medium should be carefully watched and controlled.

Throughout the entire process of pasteurization the operator should see that there are no leaks at valves or elsewhere in the apparatus. During the holding period, the pasteurizer should not be connected with the piping or fittings leading from a raw-milk storage tank or to the cooler, unless the apparatus is equipped with leak protector valves so that no incompletely pasteurized milk can escape to the cooler or raw milk enter the pasteurizer after pasteurization has started.

Where three or four pasteurizers are used, they should be so operated that as soon as one is emptied the milk in the next will have been heated and held for 30 minutes and be ready to go over the cooler. With three or four vats or tanks and a preheater, the system becomes continuous. The milk is heated to the pasteurizing temperature by the heater and then passes to the vats or tanks for holding. When the last vat or tank has been filled, the first will have been held 30 minutes and emptied, and it will be ready to be filled again. The capacity of such an outfit is considerably greater than one in which only vats or tanks are used without the preheater. Such a system, however, should have a temperature-controlled flow-diversion valve or milk pump stop (*9*) between the preheater and the vats or tanks to insure that the milk is brought to the pasteurizing temperature before it enters the vats or tanks for holding.

Using Continuous Flow Pasteurizers

In a continuous flow pasteurizer of the long-flow tubular type (*6*), the milk enters one end of a tube at the bottom of the unit and is discharged to the cooler from the last tube at the top of the unit. The pump, therefore, must be of the proper size and must be operated at the proper speed to insure that the milk is held 30 minutes. Where holders of the pocket type are used, careful attention must be given to insure that the mechanism is working properly; that the valves are opening and closing at the proper time; and that there are no leaks. The milk goes directly from the holder to the cooler. Continuous flow pasteurizers are operated in conjunction with preheaters and should be equipped with temperature-controlled automatic flow-diversion valves or automatic milk pump stops to insure that the milk enters the holders at the pasteurizing temperature (*9*). The accuracy of all continuous flow holders should be checked frequently.

High-Temperature, Short-Time Pasteurization

In the method of pasteurization known as the high-temperature, short-time method, every particle of milk must be heated to not less than 160° F. for a period of not less than 15 seconds. The equipment (fig. 4) used in this system of pasteurization may be divided into two groups, one group using electricity and the other hot water. The latter is in more common use at the present time. In all equipment for high-temperature, short-time pasteurization the rate of flow and the temperature of the milk must be under precise control, and flow-diversion valves or automatic pump stops must be provided to bypass or check the flow of milk if the temperature should fall below 160° (*9*). High-temperature, short-time pasteurization is coming into more general use. There are, however, some health departments which have not as yet approved it. Those desiring to install this system should, therefore, consult the board of health of the community in which they expect to sell their milk.

The greatest advantages of the high-temperature, short-time system of pasteurization, as compared with the holding system, are probably (1) the saving of floor space, and (2) flexibility in increasing plant volume. The volume may be increased by longer running time or by the addition of plates. Furthermore, there are no part batches which require full holding time. On the other hand, probably the greatest disadvantage of this system is that is does not lend itself to small plant operation. Plants that can pasteurize their milk with three vat pasteurizers are usually considered too small to use high-temperature, short-time pasteurization economically. Furthermore, even in the large plants, special products and cream are usually pasteurized by the batch system and not with the high-temperature, short-time system. Another fact that should be considered is that to obtain similar bacterial counts on milk pasteurized by the high-temperature, short-time system and by the long-hold system the milk should be relatively free from thermoduric bacteria. These organisms are more difficult to reduce in number with the high-temperature, short-time system than with the long-hold system.

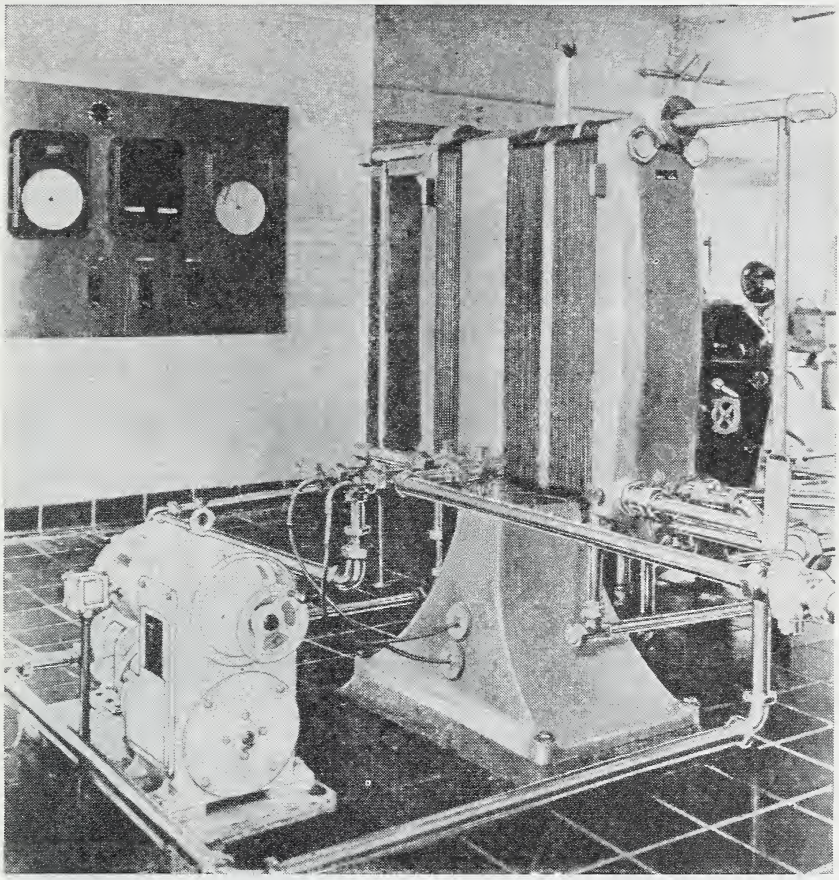

FIGURE 4.—High-temperature, short-time pasteurizer of the plate type using hot water as the heating medium. Note small floor space required.

TEMPERATURE CONTROL

One of the most important requirements in pasteurizing milk properly is accurate control of the temperature used in heating and holding the milk. Each pasteurizing system should, therefore, be equipped with a dependable thermostatic control so designed and set as to cause every particle of milk to be heated automatically to at least the required pasteurizing temperature. All automatic-discharge systems, and manual-discharge systems not equipped for heating the milk in the holder, should have an automatic milk-flow stop that will stop the forward flow of milk whenever its temperature drops below the required limit (*9*).

To insure proper pasteurization, a recording thermometer (which is a combined clock and thermometer), an indicating thermometer, and an air-space thermometer are essential (figs. 5 and 6). The recording thermometer (*9*) plays a vital part in plant operation as it shows graphically what has taken place during pasteurization. The accu-

racy and correct operation of these thermometers should be tested frequently, by use of an officially calibrated thermometer, by the plant operator as well as by health officials.

At the beginning of each run, all charts for recording the time and temperature of pasteurization should be set uniformly on the instrument dials, at the correct clock time, in order to determine the time during which the milk is held at the pasteurizing temperature. Where a continuous-flow system is used, the holding time may be checked at the beginning of the run by determining the length of time that elapses from the moment that heated milk first enters the holder until it is first discharged from the holder to the cooler. If the flow of the milk through the apparatus is properly controlled and is maintained at a constant speed, the holding time for all the milk during the entire

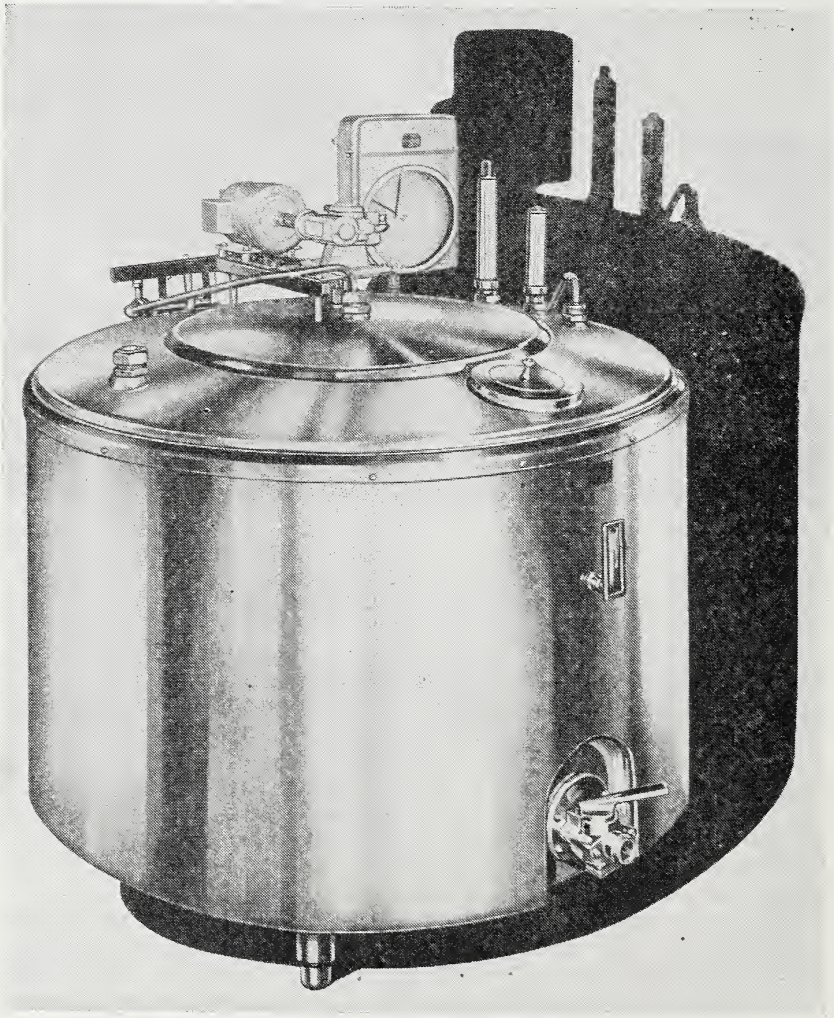

FIGURE 5.—Batch pasteurizer with a recording thermometer, an indicating thermometer, and an air-space thermometer.

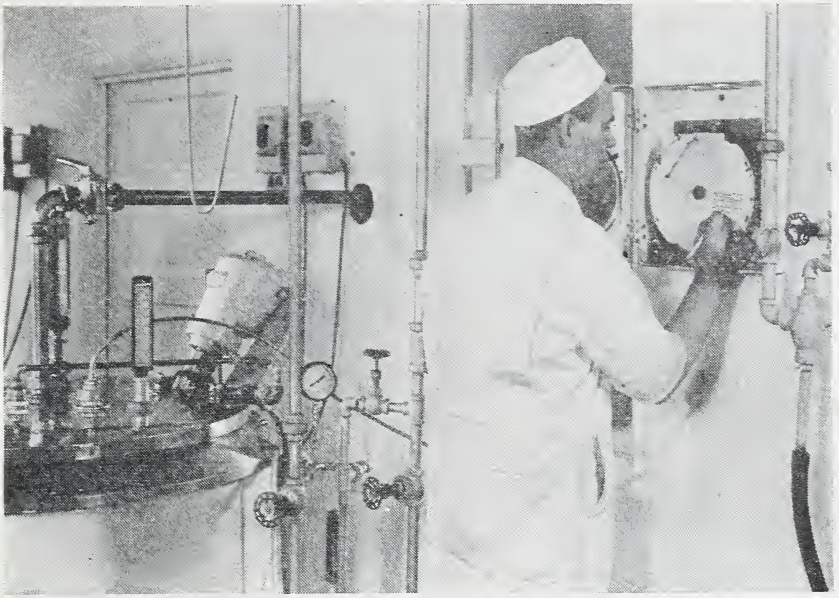

FIGURE 6.—The charts from the recording instruments constitute a permanent daily record of the pasteurizing process.

run will be the same. Where vats are used for heating and holding the milk, the chart of the recording thermometer connected with the cooler will record the temperature to which the milk was cooled and also the time when the holding period ended. Consequently, this chart, together with the chart of the thermometer attached to the pasteurizing vat, will indicate the length of time that the milk was held, provided both charts were set on the instrument dials at the same time.

There is, however, on the market a device that registers on the chart of the recording thermometer the instant of opening or closing the outlet valve of the vat or tank, and thus records directly the minimum length of time that the milk is held at the pasteurizing temperature. If the recording thermometer is not equipped with this device, and the milk is not precooled in the vat, it is often difficult to determine from the chart just when the first milk is let out of the vat. For example, if the thermometer bulb is attached near the bottom of the vat or tank the chart on the temperature recorder would show the pasteurizing temperature for the entire time that the vat or tank was being emptied, in addition to the holding period. If 30 minutes were required to empty the vat, the chart might indicate a 45-minute holding period when the first milk let out was held only 15 minutes.

As previously stated, however, the combined records from the charts at the pasteurizing vat and at the cooler, if they are properly set on the dials, will assist in determining the actual holding time.

The charts from the recording instruments constitute a permanent daily record of the pasteurizing process and, besides being necessary for the use of the plant superintendent in checking the operation of the pasteurizing department, they are often valuable in showing health officials how the process was performed (fig. 6).

Control of the Milk Flow

Accurate control of the flow of milk in milk plants, especially where the continuous-flow system of pasteurization is used, is important and requires close attention. It is essential that the flow of milk to or through the different machines or units, such as clarifiers, pasteurizers, holders (of the continuous-flow type), and coolers be so regulated that it will not exceed their capacity, but will be maintained at a uniform speed at all times. Equipment for control of the milk flow should operate automatically as far as possible and should be checked from time to time to insure accuracy.

One of the principal factors that affect the flow of milk is variations in the head or depth of milk in the tank which supplies the pump or gravity line to the heater. Whether the milk flows to the heater by gravity or is pumped, some form of float control will help to maintain uniform flow. A device used in many plants consists of a tank in which a constant depth of milk is maintained by a float, and which has an outlet of such size that it will discharge the required amount of milk per hour, either directly to the heater, if gravity flow is used, or to the feed end of the pump, if a pump is used.

The pump should be so designed that its speed cannot be changed by the operator, and should be so adjusted that the number of strokes per minute will be uniform at all times. It is important that it be kept in good repair. If the plunger, cylinder, valve, or other parts become worn, the quantity delivered per stroke will not be uniform.

In some plants the clarifier is depended on to control the flow of milk through the various pieces of apparatus. Of course, where this method of control is used, the clarifier should be operated at a constant speed and the feed of the clarifier, which is controlled by a float, should receive a constant supply of milk. All apparatus to which the milk goes subsequently must be so regulated that it will take care of the milk as fast as it comes from the clarifier. If the float in the clarifier is operating accurately, this system should provide a uniform flow of milk to the heater. When equipping new plants considerable attention should be given to properly correlating the capacities of the various machines. For example, the clarifiers, pasteurizers, coolers, and bottle fillers should be of approximately the same capacity. It is especially important that the cooler be large enough to handle the milk at all times as fast as it comes from the pasteurizers and as fast as the bottle fillers will take it away. The cooler can be slowed down more easily than it can be speeded up. Unless it is of ample capacity, the attendant will be likely to allow the milk to run over or through it too fast when he is rushed, and the milk will not be properly cooled.

Great care should be taken that valves and connections in the milk line do not leak. Leaky valves and joints result in a very insanitary condition and considerable loss of milk. Preventing milk losses is an important part of the manager's duties, and no pains should be spared to keep all valves and connections in the milk lines tight.

Cleaning the Pasteurizing and Cooling Equipment

As soon as the pasteurizing run is completed, the cleaning of the pasteurizing equipment should be begun. First the equipment should

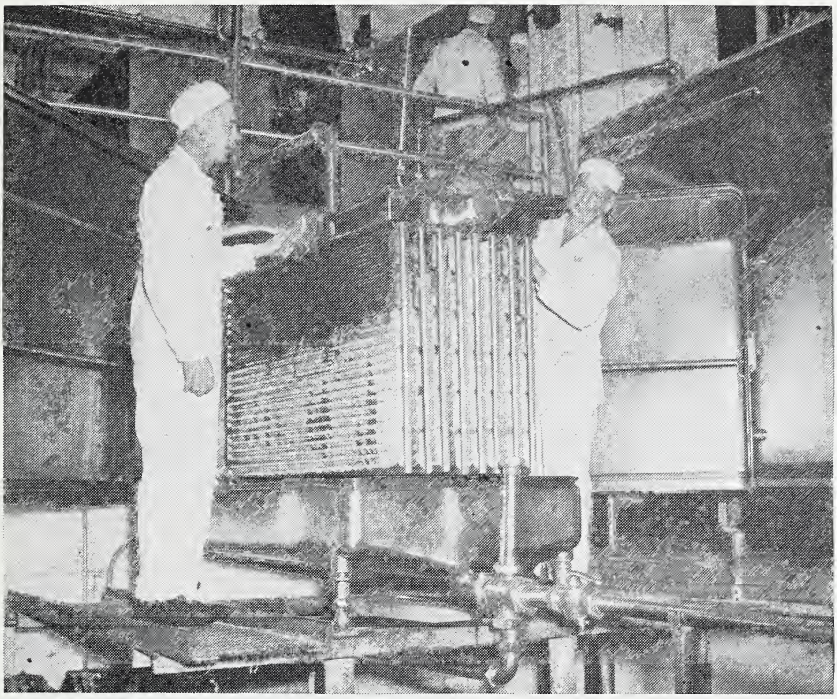

FIGURE 7.—Cleaning a tubular cooler of the cabinet type.

be thoroughly rinsed with lukewarm water. It is usually desirable to run lukewarm water through the whole system of equipment and piping, from the weigh can and receiving vat through the pasteurizing outfit, over the cooler, and through the bottle filler. As soon as the apparatus has been thoroughly rinsed, the entire system should be cleaned with hot water to which washing powder has been added. In selecting the washing material the hardness of the water should be considered. The material should be such that it will not precipitate the calcium in hard water. Avoiding calcium precipitation decreases the tendency toward the formation of milk stone. Brushes should be used to scrub off all particles of milk or casein adhering to the surfaces that have been in contact with hot milk. When heated milk is allowed to cake on the surfaces the work of cleaning becomes increasingly difficult. But if cake or "stone" has formed, mineral wool or some similar scouring material is useful in removing it. Thorough daily cleaning will prevent the cake from forming. As an added precaution, an acid-type stone remover may be used two or three times a week or as often as is found necessary.

After the vat, cooler (fig. 7), and other apparatus have been thoroughly cleaned, they should be rinsed with hot water and then thoroughly steamed or treated with a chemical agent to kill bacteria. Immediately before the milk is started through the system, the entire apparatus should be thoroughly steamed or treated with a chemical agent to kill bacteria.

Labor Required for Pasteurizing and for Cleaning Pasteurizing Equipment

In a study made at 112 city milk plants of various sizes (*7*), the amount of milk pasteurized per man-hour of labor for plants of various sizes was determined. These results are summarized in table 2.

Table 2.—*Relation between the size of plant and labor requirements for pasteurizing and cooling the milk and cleaning the equipment at 112 plants*

Milk pasteurized daily (gallons)	Milk pasteurized and cooled per man-hour		Labor required per day for cleaning pasteurizing equipment
	Excluding labor for cleaning equipment	Including labor for cleaning equipment	
	Gallons	*Gallons*	*Man-hours*
3,000 or less	439	246	3. 7
3,001 to 5,000	690	341	5. 0
5,001 to 10,000	982	434	9. 3
10,001 to 15,000	1, 290	476	17. 3
Over 15,000	1, 588	450	24. 4

These results show that labor for pasteurizing can be used more economically in large plants than in small plants. In plants of all sizes at least one man must be detailed to the pasteurizing department when it is in operation. Even in very small plants one man must spend practically all his time at the pasteurizer during the pasteurizing period to see that the apparatus is operating properly, to watch the temperatures, and to operate the valves when necessary. Since large plants usually require not more than two men and in many instances only one man to operate the pasteurizing department, the quantity of milk pasteurized per man-hour is much greater than in small plants.

On the other hand, the number of man-hours of labor used for cleaning the pasteurizing equipment is greater in the larger plants than in the smaller plants. The more economical showing at small plants in this respect, however, is partly due to the fact that the man who operates the pasteurizing equipment usually starts cleaning during the last part of the day's run, so that some of the time spent in cleaning work is not actually charged to cleaning. Large plants doubtless keep closer account of the time spent in cleaning by employees working in the pasteurizing department. Many large plants find it desirable and economical to employ a separate crew of men whose sole duty is to clean the pasteurizing equipment after the plant is shut down. Where a separate cleaning crew is employed this important task is not so likely to be slighted or rushed, to the detriment of the product, as where the pasteurizing crew must clean the equipment before they can complete their day's work. Furthermore,

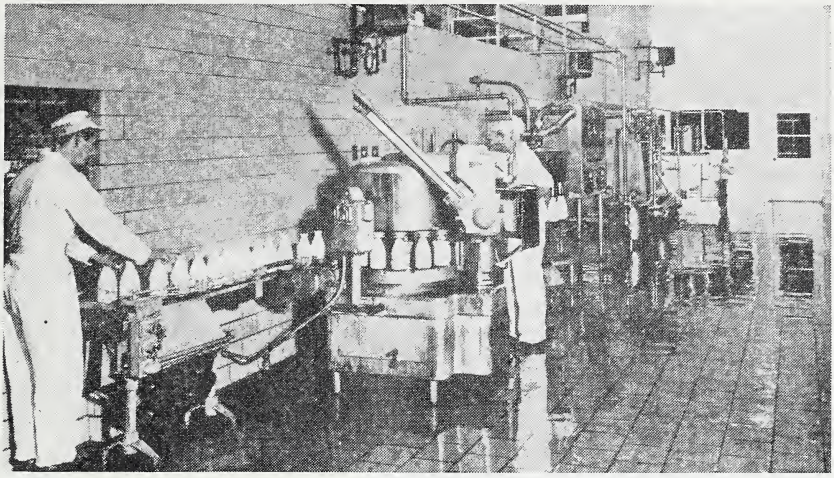

FIGURE 8.—An automatic rotary bottle filler and capper.

this system permits the pasteurizing department to be run during the full working day.

When the total amount of labor used for pasteurizing the milk and cleaning the equipment is considered (table 2), the difference between the quantity of milk pasteurized per man-hour at the small plants and at the large ones is not so great as for pasteurizing alone, but the difference is still decidedly in favor of the larger plants.

BOTTLING AND CAPPING

As soon as the milk has been pasteurized and cooled, it should be put into clean, cool bottles. Where a continuous-flow pasteurization system is used, or where a battery of tanks or vats is operated as a continuous system, the bottling and capping can be carried on at the same time as pasteurization. Therefore the capacity of the bottle fillers should be approximately the same as that of the pasteurizing outfit. In medium-sized and small plants the pasteurizing and bottling capacity should be such that the pasteurizing and bottling may be done in 4 or 5 hours. Then the same set of men can do other work during the rest of the day, such as receiving and weighing the milk and washing the bottles and cans. In small plants where only one pasteurizing vat is used, two men can weigh and dump the milk as it is received, pasteurize it, run it over the cooler, and do the filling and capping.

The bottling and capping should be done by automatic machines (fig. 8).

CLEANING BOTTLES

The bottles should be cleaned in ample time to be thoroughly cool before they are filled with milk. If the bottles are not cool, the temperature of the milk put into them is raised. This means a waste of refrigeration, and possibly increased development of bacteria. At

many plants bottles are washed in the morning and filled in the afternoon. Great care should be taken to see that the bottle washer is always in good working order, for if the bottles are not properly cleaned and treated to kill bacteria the pasteurized milk will be contaminated.

If a brush washer (*6*) which is suitable only for very small plants is used, the brushes should be changed before they become worn, and the wash water should be changed occasionally during the day. Great care must be taken to see that the rinsing and steaming device of the machine is in good working order at all times. Each bottle should receive first a strong jet of rinsing water and then a spray of scalding hot water or a jet of steam for at least 45 seconds. After the bottles are washed they should be kept in a cool, clean place until wanted for filling. It is a good plan to use special cases at the washer and transfer the bottles, after they are washed and steamed, to clean, dry cases. If the same cases that are used in the washer are also used to store the bottles, there may be a constant drip from each case into the case below; and unless the bottles are inverted in the cases, contamination may result; furthermore, these cases soon become soggy and are often not suitable for use on delivery routes.

Where an in-the-case pressure washer (*6*) is used, care must be taken to see that all the jet openings are free and working at all times and that the solutions in the various tanks are kept at the proper strengths and temperatures. The temperature of the water in the first tank should not be so high that bottles will be cracked. The temperature of the water in each succeeding tank should be gradually increased and the water in the final tank should be near the boiling point. In small machines of this type with only two or three tanks, the increase in temperature of the water in the various tanks is necessarily more sudden than in the larger machines with four or more tanks.

Medium-sized and large plants now generally use bottle washers of the soaker type (*6*), which wash the bottles after they have been removed from the cases. In large plants one man is generally employed to keep the machines in good working order and the solutions in the various tanks at the desired strength and temperature. In washers of this type, after the bottles have been cleaned, they are rinsed several times in waters of decreasing temperature, which cool them so that they can be filled immediately. From the washer the bottles pass on automatic conveyors to the fillers. Less labor is required and fewer bottles are broken under this system of washing and filling than under the indirect system, under which the bottles are washed in an in-the-case washer and then stacked to be filled later (*5*, *7*).

Although the total labor requirements are greater under the indirect system of washing and filling, some small plants may find this system more advantageous than the direct, as the initial investment is smaller and the same men who wash and stack the bottles may fill them later. In deciding which system is more economical for a particular plant, the initial cost of the two types of washers with the resulting overhead—interest on the investment, depreciation, and repairs—must be considered, as well as the comparative costs for labor, steam, and power for operation. The soaker-type washers often have

a variable speed adjustment and can be timed to synchronize with one or two fillers, depending on the capacity desired. Both small and large machines of this type are available.

After the bottles are washed, they should be treated with steam, hot water, or chemicals to kill bacteria. The large machines are usually equipped to give the bottles chemical treatment, which properly applied gives very satisfactory results. Also, fewer bottles are broken in plants where this treatment is used than in plants where steam or hot water is used, as the glass is not subjected to such sudden changes in temperature (*5*).

Bacteriological tests on the bottles as they come from the washer should be made frequently to check up on the efficiency of the machine.

Inspecting Bottles

While mechanical bottle washers generally clean the bottles satisfactorily, there are often some bottles that cannot be thoroughly cleaned in the washer without special attention. Bottles that come

FIGURE 9.—Small mechanical brush washer for washing bottles by hand.

FIGURE 10.—Inspecting bottles after they have been filled.

unwashed from the exchange or that have stood for several days, and in which the casein of the milk has dried, will sometimes pass through the machines without being properly cleaned. It is usually necessary to cull out these very dirty bottles and scrub them with a brush before they are sent through the washing machine. A good plan is to soak them overnight in a solution of washing powder. For scrubbing such bottles it is advisable to have, besides the automatic washing machine, a small mechanical brush washer (without rinsing apparatus) in which the bottles are washed by hand (fig. 9).

Besides culling very dirty bottles before they enter the machine, it is necessary to inspect all bottles after they leave the machine. It is also important to inspect all bottles after they are filled (fig. 10). Delivering milk in a dirty bottle is a serious matter from a public-health standpoint, and may also cause the loss of the customer. In large plants inspectors are often so placed that the bottles are inspected before they are filled and after they are filled. Dirt specks will usually show up more plainly after the bottle is filled with milk than before.

WASHING CANS

Washing cans is only a small part of the daily routine at a milk plant but it is a very important part, for unless the cans are thoroughly cleaned the quality of the milk will be impaired. Many different methods are used in caring for the emptied cans and there are several different types of can-washing machines on the market. However, in

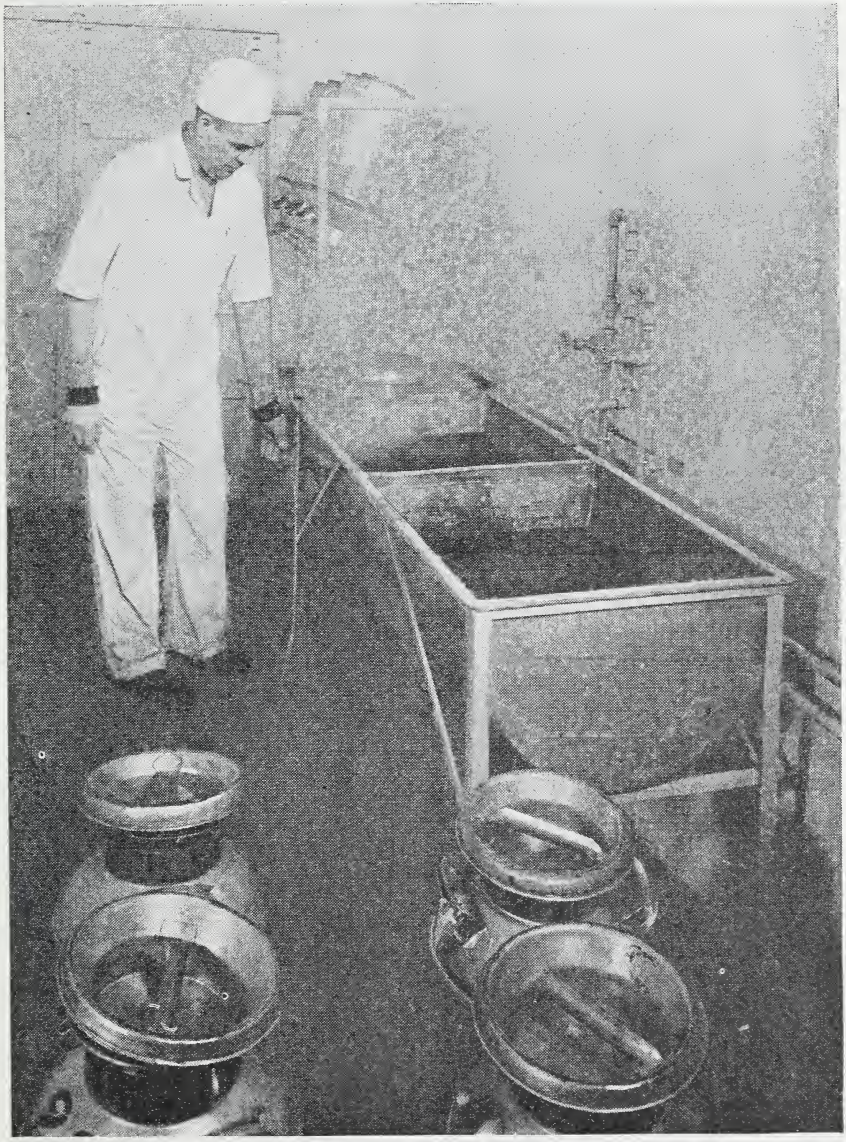

FIGURE 11.—Small-plant equipment for steaming cans.

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the use of all efficient machines the principal object is thorough cleansing with a solution of washing powder and water, followed by rinsing, steaming, and rapid drying. After the cans are dry they should be covered and kept from contamination. The large machines are fitted with powerful pumps, and while the cans, inverted, are being run through the machine, sprays of a solution of an alkali or an acid detergent and water, of rinse water, of hot water, and of steam are successively forced into the cans under considerable pressure. The cans are dried in the same machine by a blast of hot air. When they leave the machine they should be clean, dry, and odorless.

Satisfactory results can be obtained at small plants by washing the cans thoroughly with a hand brush and water to which washing powder has been added. The cans should then be rinsed and steamed with a jet of live steam for at least 45 seconds (fig. 11). After steaming, the cans should be allowed to stand for a few seconds until thoroughly dry. At small plants they may be dried on a rack. This would require an extra set of cans, as the producer or truckman must have his cans immediately, and such a method would not be practical for large plants.

Steaming and drying the cans is very important. They should be steamed until they are too hot to handle with the bare hands and will become dry in a few seconds. Not only does drying leave the can in a good sanitary condition, but it helps to prevent rusting and to prolong the life of the can. The covers should be thoroughly cleaned and steamed before being returned to the cans. Many large plants use machines that automatically put the covers on the cans after they have been washed, steamed, and dried.

MILK-PLANT SANITATION

The importance of cleanliness in handling milk cannot be overestimated. The plant operator is responsible for the quality of the milk after it is received at the city plant, and he must keep the plant and equipment in a sanitary condition at all times in order to be able to put out a high-quality product. Every surface with which the milk comes in contact must be thoroughly cleaned and treated with steam or chemicals (where chemicals are permitted) in order to kill bacteria. The equipment must be kept in good repair and rough or rusty surfaces with which the milk may come in contact should be eliminated, as they are difficult to keep clean and free from bacteria.

On arrival at the plant, the milk should either be cooled and put in a cold place or immediately started on its course through the plant. The cans may be put into the refrigerator or have ice packed around them, or the milk may be stored in tanks provided for the purpose. These tanks should be in a cold room or be insulated or jacketed, so that the milk may be kept at a low temperature until it is passed through the plant.

In passing through the various pieces of apparatus the milk should be exposed to the air as little as possible; and after it is pasteurized, cooled, and bottled it should be kept in the milk-storage room until taken to the delivery wagons. It is essential that the milk be cooled to 50° F. or below and held there until delivered to the consumer. In the milk-storage room a temperature of 40° or below should be maintained.

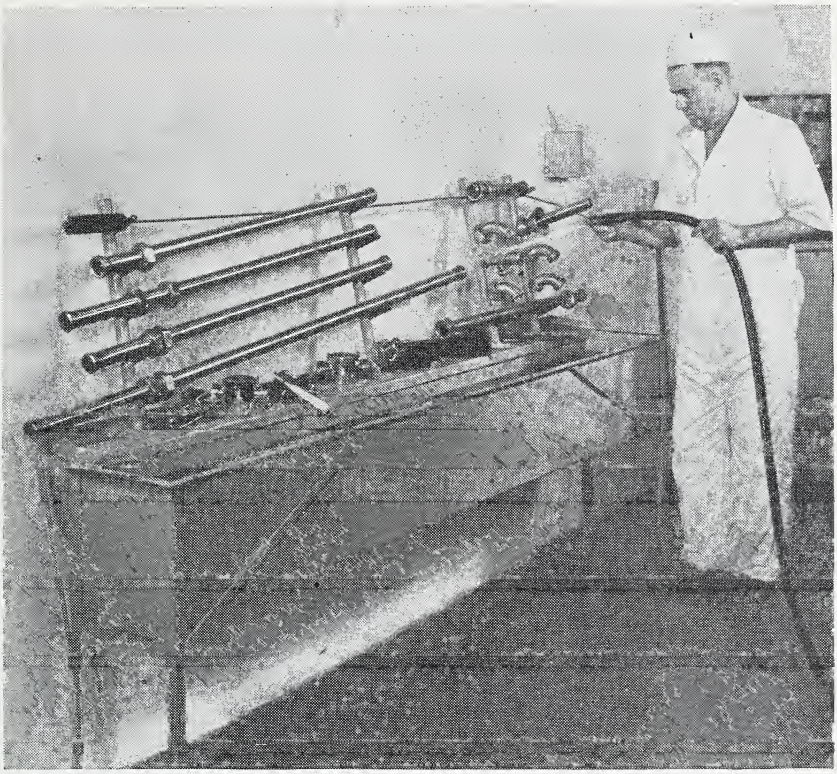

FIGURE 12.—Sanitary milk piping disconnected, washed, and steamed.

As soon as all of the milk is bottled, all parts of the milk-handling apparatus should be cleaned thoroughly by first rinsing in cool or tepid water, then washing with hot water to which washing powder has been added, and finally treating with boiling hot water or steam or a chemical agent. After the milk has passed through the apparatus it is a good plan to pump cool water through the entire system first, and then hot water to which washing powder has been added. The pumps and pipes can be rinsed immediately after use, by pumping water through them. They should then be taken down and thoroughly washed, and this can be done easily if there are numerous hand couplings in the pipes (fig. 12). After being washed and rinsed the pumps and pipes should be treated with steam, water at or near boiling temperature, or a chemical agent.

Cleaning and steaming the milk piping and pumps are often neglected. If the pipes are not taken apart, and thoroughly cleaned and steamed each day, filth and dirt will soon collect at joints and elsewhere, and the milk passing through such apparatus will be badly contaminated and will be of poor quality. Great care should be taken in cleaning the pasteurizing outfit. This should be rinsed immediately after being used, and then thoroughly cleaned and finally rinsed and steamed.

Flies should be rigorously excluded. All windows and doors should be well screened. The door should open outward, and revolving fans

placed near it and blowing toward it will often keep many flies from entering the plant by providing a constant breeze which forces the flies out as the doors are opened. Good ventilation is essential (*4*).

Keeping a milk plant clean is a simple matter for a person who bears in mind the fundamentals of sanitation and has a fair idea of bacteriological principles. Everything with which the milk comes in contact should be kept clean from a bacteriological standpoint. Milk should be exposed to the air as little as possible; it should be pasteurized at 143° to 145° F. for 30 minutes or at 160° for 15 seconds, cooled to 50°, and kept at 50° or below until delivered.

Special attention should also be given to cleanliness of the delivery outfit. Many dealers naturally take great pride in the appearance and cleanliness of their plants, but customers have an opportunity to see the delivery outfits every day, while only a few ever visit the plants. Delivery trucks should be well painted and washed. Drivers should be clean, neatly dressed, courteous, and obliging. Many a good customer has been lost by a discourteous driver, while many a new one has been gained by a polite and obliging driver. A uniform or white suit adds much to the driver's appearance. Where cash sales are made in office buildings or other places in which the customer deals directly with the driver, a clean white suit is especially desirable.

Treating Equipment to Kill Bacteria

After the milk-handling equipment has been thoroughly cleaned with a solution of washing powder and scrubbed with brushes whenever necessary, it must be thoroughly rinsed and treated with heat or a chemical agent (*8*) to kill the bacteria.

HEAT TREATMENT

Hot water or steam, thoroughly applied, will kill most of the bacteria on the equipment after it has been properly cleaned. Steam, however, is effective only when it can be somewhat confined. Open surfaces are very difficult to treat properly with steam from a steam hose, because not enough heat can be applied to kill the bacteria on account of absorption of heat by the surrounding air. For such surfaces hot water is more effective than steam. Water at the boiling point or as near it as possible should be used, otherwise the treatment will not be effective. Of course, the first water will cool off when it comes in contact with the surface to be treated and it should be flushed for not less than 5 minutes with water at a temperature of at least 165° F. Thermometers or temperature recorders may be used to check the temperature of the water. For closed surfaces, such as pipes, internal-tubular heaters, holders, and coolers, steam may be applied and confined in the apparatus with very satisfactory results.

CHEMICAL TREATMENT

Chemical treatment of milk-handling equipment has become very common during recent years. Chlorine as a compound or as a gas is the chemical used, and it may be purchased in such forms as sodium hypochlorite, calcium hypochlorite, and compounds containing chloramines. These compounds may be purchased under various trade

names. Before any chemical treatment is used it should be ascertained whether the local health authorities recognize and permit its use.

Small equipment, such as fittings, pump parts, filter parts, etc., can best be treated by immersing them in a tank containing the solution. Each piece of apparatus should remain immersed in the solution for at least 2 minutes. Large equipment, such as coolers, vats, etc., can best be treated by spraying. The sprayer should be of the pressure type, and the entire surface to be treated should be covered with a fine spray. The solution applied as a spray should be about double the strength of that in which the apparatus is immersed.

Home-made chlorine compounds usually cost less than those purchased. However, some labor is saved by using the commercial solutions, as no stock solution need be prepared, and their strength is usually more uniform. Directions for making calcium hypochlorite and sodium hypochlorite solutions may be obtained from the Bureau of Dairy Industry.

Very satisfactory results are obtained with the chemical treatment of bottles after they have been thoroughly cleaned and rinsed. The solution with which they are treated must be kept at the proper strength. Its available chlorine content should be not less than 50 parts of chlorine per million parts of water. On the large soaker-type bottle washers chlorine gas may be used to advantage, the gas being fed automatically to the treating solution. Where this system is operating properly, a solution of the proper strength can be depended on to give goods results.

When chemical solutions are used for the treatment of dairy apparatus or utensils proper care should be taken to thoroughly drain off all solution after treatment.

MILK-BOTTLE LOSSES

Replacement of lost and broken milk bottles is one of the heavy costs in handling and distributing market milk. The records of 76 milk dealers in various cities showed that the life of the milk bottle ranged from 6 to 91 trips; the average was 37.32 trips, while the most common figures given ranged between 20 and 30 trips.

Many bottles are broken in the plant, but considerable progress has been made in reducing this loss, both by more efficient arrangement of plants and equipment (*5*) and by impressing on workmen the importance of handling the bottles carefully. Some dealers keep daily records of the amount of glass broken in the plant, and these tend to make the men more careful in handling the bottles.

It is important that the bottle crates or cases be kept in good repair and hold the bottles firmly, especially where the cases are transferred in the plant over gravity conveyors.

Every milk plant should have a system of checking the drivers on the number of bottles brought back each day. Losses will usually be much greater in plants where no record of the number returned by each driver is kept, even though no commission is paid for returned bottles by plants keeping records.

Cooperation of all dealers in a particular locality is necessary for satisfactory results in reducing losses of bottles.

Some of the methods being used in various localities are:

(1) A charge is made for all bottles sold to stores. One of the principal points of loss is stores where no charge is made for the bottles. If there is no incentive for customers to return the empty bottles, the customers are not likely to do so. Many consumers are not properly informed of the value of the milk bottles, and do not realize that they are the property of the dealer. They will often throw the bottles into the refuse can, break them, or otherwise destroy them. Where the same type of bottle is used for both store trade and family trade, a ticket may be given to the store customer when he pays for the bottle and the amount he pays is returned upon the surrender of the ticket and a bottle. If an empty bottle is surrendered when a bottle of milk is taken away, no ticket or payment is required. In many localities a special bottle is used for sales at stores. For these bottles a price is charged and no ticket is necessary, as such bottles may be redeemed at the store for the price charged at any time. The use of the store bottle greatly reduces the loss of milk bottles. The number of bottles handled by the exchange in one city was reduced more than 50 percent after the use of the special store bottle was adopted. If the use of the special store bottle is to be successful, all dealers in a city must agree to charge the same price for the bottles delivered to stores and to live strictly up to the agreement.

(2) A charge is made for all bottles delivered to family trade and the driver is usually held responsible for all bottles which he takes out on his route and is charged for any shortage. The driver in turn is permitted to charge his customers for bottles not returned to him if he considers this advisable. This system naturally gives the driver an incentive to get in all the bottles possible. He uses his own judgment in charging his customers for shortage of bottles. Generally this is not necessary as, by impressing upon the customers the fact that he himself is charged for all shortages, he can usually persuade the customers to return the bottles.

In some places a modification of this system is used, the dealer also giving the driver credit for stray bottles from other dealers, and using all bottles returned, including strays. Usually there is a limit to the number of extra bottles that will be paid for, and any returned over this limit are credited to the driver to take care of future shortages. While the system of using all bottles, including strays, is not to be recommended, considerable labor in the plant may be saved by this system, as no sorting is required. In a city where this system of pooling bottles was adopted, one dealer operating about 80 routes was enabled to dispense with three men who had formerly been employed in sorting out stray bottles. Before such a system can be employed in any city, however, it is usually necessary for all of the dealers to cooperate, and if there is a local regulation forbidding the use of stray bottles, to get this regulation suspended. One of the principal objections to the use of this system is that it encourages the drivers to take bottles belonging to drivers for other plants. Furthermore it is often difficult to get all of the dealers in a locality to cooperate in such a plan.

(3) The use of a universal or association bottle for both family and store trade. Where this bottle is used, all bottles are the same for all dealers. The bottle usually has a distinctive mark on it, together with the name of the milk dealers' association, and it is easily dis-

tinguished from other bottles. As a rule each dealer pays into the bottle fund an initial amount prorated in accordance with the number of bottles of milk he sells daily. After a dealer has purchased his initial supply, he can draw as many bottles as he desires from the general supply each month. The association determines at the end of the month the total cost of all bottles delivered to all the dealers, and this amount is prorated among the dealers in accordance with the amount of business they do daily. However, where it happens that a dealer overdraws or underdraws his quota, he is debited or credited so much per bottle for all bottles overdrawn or underdrawn. In this way each dealer pays his share of the cost of the bottles used by all dealers in proportion to the amount of business he does, and if he draws more or less than his quota of bottles from the general supply he is debited or credited for the difference.

(4) Route drivers are paid a commission based on the number of bottles returned. There are various methods of basing such a system, but one of the most common is to pay a certain amount for each bottle returned daily in excess of a certain percentage (as 90 percent) of all bottles taken out on that day. Usually an equal amount is deducted from the driver's commission for each bottle that he is short at the end of the day, up to 90 percent of the number charged to him.

(5) By bringing to the attention of consumers the value of milk bottles and the importance of returning them regularly many dealers have reduced their bottle losses considerably. The following notice which one dealer distributes to his customers calls their attention to the importance of returning the bottles:

PLEASE PUT OUT ALL
EMPTY MILK BOTTLES
EACH EVENING

I am delivering more full bottles than the empties returned.

I am held responsible for all BOTTLES SHORT.

PLEASE HELP ME TO STOP THIS LOSS

Your Milkman.

(6) Dealers in many localities establish milk-bottle exchanges to reduce the loss from stolen or misplaced bottles. These exchanges operate in many of the larger cities and serve as clearing houses. Stray bottles collected by route men are sorted and sent to the exchange, where they are resorted, and in many cases, washed. Usually from one-fourth to 1 cent per bottle is paid to the dealer from whom the stray bottles are received, and he is charged from 1 to 2 cents for each bottle returned to him. Some exchanges do not pay the dealer for the stray bottles he turns in. Bottles brought in by junkmen and other collectors are paid for at from 1 to 2 cents each. In one large city the exchange receives and returns to the owners more than 1,000,000 bottles a week. About one-third of these strays are salvaged by junk-

men and other collectors, and many of these strays are gathered from the city dumps. Such bottles are difficult to clean and, if not washed at the exchange, should receive special attention at the city plant.

Some exchanges make a small profit, but their object is not to make a profit but to assist in getting bottles back to their owners. Usually the exchange is owned by the dealers, and when the receipts are much greater than the expenses for a continued period of time the surplus is divided among the dealers according to the amount of business done with the exchange.

(7) Using a single-service container for milk, of course, would eliminate the loss of bottles. Such containers are in use in many localities, especially for store trade. This system eliminates the collection and washing of bottles, and requires less space on delivery wagons and in the milk-storage room of the plants. The containers are convenient for the stores, which do not have to bother with returned bottles.

At the present cost of glass bottles and the cost of collecting and washing, as compared with the cost of single-service bottles, the single-service container is not able to compete successfully in cost with the glass bottle for family trade, even though the life of the glass bottle is only about 30 trips.

GOODS RETURNED FROM DELIVERY ROUTES

Another source of loss and expense in the milk business is the large amount of goods returned from delivery routes and the uneconomical disposition of such goods. Of course, it is desirable that the driver keep his returns as low as possible and at the same time have enough goods to supply his customers. It is sometimes difficult for him to figure closely enough and he has to carry considerable extra milk which may have to be returned. He should, however, make a special effort to figure his needs as closely as possible.

The figures in table 3 were obtained from a dealer operating 25 routes and show the quantities of various goods returned, expressed in percentage of those taken out.

TABLE 3.—*Quantities of various goods returned at a representative plant with 25 routes, in percentage of goods taken out*

Goods	Goods returned		
	Total, year	Month of October	One Monday in October
	Percent	*Percent*	*Percent*
Gallons milk (bulk)	5. 0	2. 0	4. 5
Quarts milk	4. 3	4. 0	4. 5
Pints milk	5. 2	6. 0	7. 5
Half pints milk	3. 1	4. 0	7. 0
Quarts certified milk	6. 4	6. 0	6. 2
Quarts buttermilk	20. 0	22. 0	26. 0
Gallons cream	6. 6	10. 0	12. 0
Quarts cream	4. 0	3. 0	6. 3
Pints cream	16. 0	16. 0	20. 0
Half pints cream	8. 8	9. 0	11. 0
Half pints whipping cream	25. 0	23. 0	23. 2

Among the methods used to keep the volume of returned goods as low as possible are:

(1) Using the quantity of goods returned by the route salesman as one of the points on which his commission is based. This, however, should be counterbalanced by a commission on sales, so that there will be an incentive for the driver to take out enough goods to supply his customers and to make extra sales.

(2) Giving prizes each month to drivers who return the least goods during the month.

(3) Requiring drivers to pay 1 cent per bottle for all goods returned above 6 percent of those taken out.

Among the most common methods of disposing of returned goods are: Selling them the same day for cash at the plant or for special orders; selling them to peddlers the same day; selling them on the wholesale routes the next day; selling them on the retail routes the next day; separating and selling the cream to the trade the next day; separating and selling the cream to ice-cream dealers or creameries or disposing of it through the butter, ice-cream, and cheese departments of the plant; selling milk to cottage-cheese dealers; using them in the manufacture of casein, milk sugar, albumen, etc.; using them in the manufacture of buttermilk; and using them in the manufacture of sour cream.

Each dealer has to study his own conditions, since the best method for one dealer may not be suitable for another. Most dealers, however, seem to favor dumping all returns and disposing of the cream for butter and ice-cream purposes. A second grade of buttermilk obtained by making butter from this cream can also be disposed of to bakeries. In this way returns are handled at small expense, and the danger of old milk going out to the trade from this source is eliminated. Using returned milk the next day on delivery wagons should be discouraged and is prohibited by the health departments of many localities.

Using Returned Homogenized Milk

Homogenized milk cannot be separated efficiently. Dealers who distribute homogenized milk are therefore confronted with the problem of how to dispose profitably of the milk returned from the routes. Some dealers use it in making chocolate milk, cultured buttermilk, and ice-cream mixes.

A new way to use returned homogenized milk is to mix it with skim milk to make creamed cottage cheese. As much as 50 percent of homogenized milk may be used in the mixture. The curd should be cut when the acidity of the whey is not over 0.5 percent; hot water, in quantity up to 50 percent of the volume of milk, should be added immediately and the curd heated so that it will be sufficiently firm within 1 hour. When 50 percent of homogenized 4-percent milk is used, the curd will contain approximately 11 percent fat. Therefore, it is not necessary to add more butterfat and instead of creaming in the usual way the process is completed by using skim milk. Seventy pounds of skim milk to 100 pounds of curd will give a finished product which contains approximately 6 percent butterfat. When less than 50 percent of homogenized milk is used, the skim milk that

is added will necessarily have to be enriched in proportion to the amount of fat in the curd from the homogenized milk; or when the quantity of returned homogenized milk is small, it may be enriched and used for creaming cottage cheese made from skim milk.

DISPOSAL OF SURPLUS MILK

Although various systems of buying milk have been worked out whereby the prices paid have a tendency to induce producers to adjust their production to the local demands for market milk and thus to reduce the surplus received, surplus milk and its economical disposal is nevertheless an important problem for milk-plant managers. Each milk-plant operator must determine for himself how to dispose of a surplus to best advantage in his particular locality. Market demands and prices are, of course, the important factors in determining what products can be manufactured most advantageously from the milk that cannot be disposed of at market-milk prices.

The following calculations illustrate how the returns may be figured on various products that can be made from surplus milk. The values here attached to the various products are arbitrary, and the actual prices will depend, of course, on conditions and locality. The following arbitrary values are used:

Butter	per pound	$0.60
Cottage cheese	do	.10
Sweet cream	per gallon	2.00
Churned buttermilk	do	.30
Cultured buttermilk	do	.40

Value of products from 100 pounds of surplus milk, at assumed prices

Butter, cottage cheese, and churned buttermilk:	
The cream from 100 pounds of 4-percent milk will make approximately 4.75 pounds of butter, at 60 cents	$2.85
And 1 gallon of churned buttermilk, at 30 cents	.30
The skim milk will produce approximately 11 pounds of cottage cheese, at 10 cents	1.10
	4.25
Sweet cream and cottage cheese:	
100 pounds of 4-percent milk will make approximately 2.4 gallons of 20-percent cream at $2	4.80
And approximately 11 pounds of cottage cheese, at 10 cents	1.10
	5.90
Butter and cultured buttermilk:	
100 pounds of 4-percent milk will make approximately 4.75 pounds of butter, at 60 cents	2.85
And approximately 10 gallons of cultured buttermilk, at 40 cents	4.00
	6.85
Sweet cream and cultured buttermilk:	
100 pounds of 4-percent milk will make approximately 2.4 gallons of 20-percent cream, at $2	4.80
And approximately 9 gallons of cultured buttermilk, at 40 cents	3.60
	8.40

Thus, at the prices given, it would be more profitable for the milk dealer to separate the surplus milk and sell the sweet cream and make cultured buttermilk from the skim milk. As stated, however, these figures are given merely for illustration; the cost of manufacture, market demand, and the prices that can be procured for the products must be considered in each case. Such illustrations will assist a dealer in determining what prices he can afford to charge for certain products as compared with prices of other products, as well as in determining what products can be made most advantageously from his surplus milk. The market for cottage cheese is often limited and irregular. Usually there is a good demand for good butter, and many plants are able to make a considerable number of cash sales of butter and buttermilk at the plant as well as deliver it on the routes to their regular trade. Whether sweet cream can be disposed of readily depends on the locality.

Some dealers who have a large surplus manufacture it into less perishable products, such as condensed and powdered milk, casein, etc., but, of course, this practice would not be practicable for a small plant. In the case of all products the relative cost of manufacture and marketing must be considered.

SHRINKAGE IN HANDLING MILK AT PLANTS

Shrinkage of milk in handling is an important item and should be kept as low as possible. Table 4 gives the shrinkage for a series of days at three plants.

TABLE 4.—*Shrinkage of milk at three city plants*

Plant	Daily receipts at plant	Quantity bottled	Daily loss	
	Gallons	*Gallons*	*Gallons*	*Percent*
No. 1	1, 221	1, 184	37	3. 0
	1, 000	976	24	2. 4
	1, 200	1, 162	38	3. 2
	1, 100	1, 071	29	2. 6
Average	1, 130	1, 098	32	2. 8
No. 2	1, 324	1, 299	25	1. 9
	1, 295	1, 274	21	1. 6
	1, 492	1, 468	24	1. 6
	1, 395	1, 385	10	. 7
Average	1, 376	1, 356	20	1. 4
No. 3	1, 049	1, 004	45	4. 3
	1, 021	979	42	4. 1
	1, 087	1, 046	41	3. 8
Average	1, 052	1, 009	43	4. 1

In a special study made at plant No. 1 the amount of shrinkage of milk was determined for a period of 21 consecutive days. The average daily loss was 3 percent of the quantity handled. A special effort was then made to determine the sources of avoidable loss and to reduce the loss as much as possible. After systematic efforts to reduce the losses were made and a regular system of checking the losses was put into practice, the shrinkage was reduced to less than one-half the former quantity, and for 16 consecutive days the average daily loss was 1.48 percent, ranging from 0.9 to 2.2 percent of the quantity handled.

While the amount of shrinkage will differ at different plants, plants which are well arranged and equipped and efficiently operated will usually keep it down to about 1 percent of the quantity of milk handled, or less.

Causes of Shrinkage

Losses from shrinkage and milk shortage in the plant are largely due to the following causes: Careless handling of cans in transferring from cars or trucks and in dumping; incomplete draining of cans; leaky or battered apparatus; losses at the filler caused by fillers being out of repair, by leaky or improperly adjusted valves, carelessness in handling bottles, breakage of bottles, etc.; carelessness in handling full cases of milk, thus breaking the bottles; loss from milk left in the pasteurizer, pipes, pumps, tanks, or other apparatus; evaporation and mechanical losses in pasteurizing, separating, homogenizing, and clarifying the milk; loss by transferring milk and cream from bottles to cans, as in handling milk and cream returned from the routes; shrinkage in cooling milk; breakage of bottles in transferring cases on conveyors, due to poorly constructed cases or to improperly arranged conveyors.

If the milk is weighed at the plant, the first two causes listed would not result in loss of milk to the dealer but the producer would not receive credit for all the milk sent in. There is necessarily a certain amount of shrinkage in transferring milk from cans to bottles and in the processes of pasteurizing and bottling. Special attention, however, should reduce these losses considerably. Collecting pans should be placed under all milk apparatus where milk is apt to spill, and especially under the filling machines.

CHECKING MILK THROUGH THE PLANT

Every milk plant, whether large or small, should have as part of an adequate accounting system a method of keeping a check on all milk received and handled through the plant and of checking the route salesmen (fig. 13). Following are given some of the forms that may be used for these purposes at small or medium-sized plants. No attempt to describe the general accounting system is made.

FIGURE 13.—Checking out routes at a milk plant. The goods delivered to each driver are charged by the checker on a driver's order (Form 7).

CHECKING GOODS HANDLED IN PLANT

Many milk losses in a plant are sometimes overlooked. For example, a driver may go out with more milk than is charged to him, or he may receive credit for returning more milk that he actually returns, or milk may be sent out on special delivery and not be charged. In order to check up such mistakes and losses, a balance of all goods handled at the plant should be made out each day.

The daily stock balance sheet shown in Form 1 is adaptable for use in any milk plant which operates up to 10 or 15 milk-delivery trucks and handles very little butter, cheese, or other manufactured goods; it is especially suitable for use in a branch plant which receives most of its special goods, such as cream, chocolate drink, butter, etc., from the main plant. This stock balance is used as follows:

An inventory of the stocks on hand may be taken at any definite time during the day, depending upon conditions at the plant, as 6 p. m.; but the inventory should be taken at the same time each day and must be carried forward on the balance for the following day. For example, the quantities of milk, cream, and other products credited in the horizontal column headed "Stocks on hand at 6 p. m.

Tuesday," which is shown near the bottom of the sheet, are carried forward to the top column of the upper or debit side of the next sheet as "stocks on hand" to be accounted for on the following day (Wednesday). To this item are added all goods received at the plant from producers and other receipts during the day. The total of these three items is the total amount of stocks to be accounted for on that day. On the lower half or credit side of the balance are entered all sales, known losses, etc. The sum of the total quantity of each kind of goods thus credited and the quantity on hand should equal the total amount to be accounted for.

In the line headed "Transferred" on the upper or debit side of the sheet are entered the quantities of cream, skim milk, etc., made from other products, as, for example, cream of a medium butterfat content made from heavy cream and skim milk, or cream and skim milk obtained by separating whole milk. The quantities of these new goods are to be added to the stocks on hand and the receipts, in order to determine the "total stocks to be accounted for." To balance the account it is necessary to enter the quantities of old goods used for these purposes on the credit side under "Transferred." Thus, if 100 gallons of whole milk were separated into 10 gallons of cream and 90 gallons of skim milk, the 100 gallons of whole milk would be entered on the credit side of the balance and the 90 gallons of skim milk and 10 gallons of cream would be entered on the debit side; or if 100 gallons of cream of medium butterfat content were made from 80 gallons of heavy cream and 20 gallons of skim milk, the 100 gallons of medium cream would be entered under "Transferred" on the debit side and the heavy cream and skim milk would be entered under "Transferred" on the credit side of the balance sheet.

If all records are carefully completed each day, there should be only a small surplus or shortage unaccounted for at the end of the day. If on any day a considerable shortage is shown, the plant superintendent should immediately attempt to find its cause.

Another plan for balancing the stock handled at the plant during the day is the use of Form 2. This sheet is designed more especially for plants with, in addition to the market-milk department, other departments, such as cream or separating department, butter department, etc. This balance should be supplemented by other checks, such as "separator report," "butter-department report," "pasteurizing and bottling report" (Form 3), etc. All goods received are debited, and all goods sent to the routes or to other departments, known losses, etc., are credited. Form 2 may be used by plants of all sizes. It does not, however, supply a check on any losses on the routes because the entries on the credit side show the quantities of goods delivered to the drivers and not the actual sales as does Form 1.

Form 1.—Daily Balance of Stock

Date_____19____

DEBIT

	Milk				Special milk		Butter-milk		Skim milk		Cream				XX cream			Chocolate drink			Butter, pounds
	Gallons	Quarts	Pints	½ pints	Quarts	Pints	Gallons	Quarts	Gallons	Quarts	Gallons	Quarts	Pints	½ pints	Quarts	Pints	½ pints	Quarts	Pints	½ pints	
Stocks on hand, 6 p. m., *Monday*	200	1,600	800		50		10	200	10			10	30	200	22	6	20			200	30
Received from producers	800																				
Received from main plant																					
Other receipts					50		10	180				10	20	200	2	5	15			220	50
Transferred											[1] 10										
Total stocks to be accounted for	1,000	1,600	800		100		20	380	10		10	20	50	400	24	11	35			420	80

CREDIT

Sales, Route 1	20	200	50		6		5	50				5	5	50	1		5			50	10
Route 2	5	300	100		10			50						30		3	5				
Route 3	50	250	100		4			20				2	5	25		2				50	10
Route 4	50	200	150		10			30					2	25							
Route 5	50	200	50		10			10				3	10	20			3			20	
Route 6 (etc.)		350	150					10					3	20						30	
Office sales		30	10		5									10			2				5
Special deliveries		50	20				3	20			[1] 10		2		2	2	8			20	10
Shrinkage in pasteurizing and bottling department	10																				
Other known losses		10	10										1	4						2	
Returned to shippers	5																				
Returned to main plant	10				2			5													
Transferred									[1] 5						[1] 20						
Total amount credited	200	1,590	640		47		8	195	5		10	10	28	184	23	7	23			172	35
Stocks on hand, 6 p. m., *Tuesday*	300	1,670	800		53		12	184	5			10	22	214	1	4	12			248	45
Total stocks accounted for	500	3,260	1,440		100		20	379	10		10	20	50	398	24	11	35			420	80
Over		1,660	640																		
Short	[2] 500							1						2							

[1] 10 gallons of cream were made from 20 quarts of XX cream and 5 gallons of skim milk.
[2] Net shortage of milk, 500−(1660/4+640/8)=5 gallons.

FORM 2.—DAILY BALANCE OF RECEIPTS AND DISPOSALS OF STOCK AT PLANT Date _____19___

DEBIT

	Milk		Special milks		Cream		XX cream		Buttermilk		Skim milk		Chocolate drink		Butter, pounds	Miscellaneous
	Gallons	Pints	Gallons	Pints	Gallons	Pints	Gallons	Pints	Gallons	Pints	Gallons	Pints	Gallons	Pints		
Stocks on hand, 6 p. m. (*previous day*)	2,000	6	10		80	2	20		280		100		10			
Received from producers	2,000															
Received from branches			10										10			
Standardizing																
Returned from routes																
Manufactured					[1] 40				[2] 300							
From separator							[3] 50				[3] 450					
Total receipts	4,000	6	20		120	2	70		580		550		20			

CREDIT

Returned to shippers																
To retail routes	1,500		10		60		20		290				10			
To wholesale routes	400															
To retail department of plant																
Special deliveries	100															
To separator	[3] 500															
To ice cream department																
To butter department																
To standardizing							[1] 20				[1] 20					
To buttermilk											[2] 300					
To chocolate drink																
Other deliveries																
Known losses	30				2				10					4		
Stocks on hand, 6 p. m. (*today*)	1,470		10		60		30		280		230		9	4		
Total distribution	4,000		20		120	2	70		580		550		20			
Over																
Short		6														

KNOWN LOSSES

Spilled and leaked																
Breakage						2			5							
Drunk by employees																
Shrinkage in pasteurizing and bottling	30								5					4		
Loss in separating																
Loss in dumping returns																
Other losses																
Total losses	30					2			10					4		

[1] 40 gallons of cream were made from 20 gallons of XX cream and 20 gallons of skim milk.
[2] 300 gallons of buttermilk were made from 300 gallons of skim milk.
[3] 50 gallons of XX cream and 450 gallons of skim milk were separated from 500 gallons of milk.

Checking Losses in Pasteurizing and Bottling

The accompanying form (No. 3) may be used to check the losses of milk and other products that take place during the processes of pasteurizing and bottling. Such shrinkages may be reported in both volume and percentage. Such a check should be kept at all plants and should be used in conjunction with the daily balance of stock. (Form 1 or Form 2.) The quantity lost as indicated by Form 3 will be entered under this item on the credit side of Forms 1 or 2 showing daily balance of stock at plant.

Form 3.—Pasteurizing and Bottling Report

Date_____ 19____

	Milk				Buttermilk		Cream				Chocolate drink		
	Quarts	Pints	½ pints	Total gallons	Quarts	Total gallons	Quarts	Pints	½ pints	Total gallons	Pints	½ pints	Total gallons
Receipts of the pasteurizing and bottling department:													
Milk and cream received from the producers				2,000						50			
Cream received from separator department										150			
Other receipts (buttermilk, chocolate drink, etc.)						300							10
Total receipts of pasteurizing and bottling department				2,000		300				200			10
Products delivered to the cold-storage room by the pasteurizing and bottling department	6,000	3,000	1,680	1,980	1,192	298	112	160	2,400	198	20	120	10
Excess (+) or shrinkage (−):													
Gallons				−20		−2				−2			
Percent				1.00		0.66				1.00			

Checking the Shipping and Receiving Clerks

Unless the proprietor himself checks the route men out and in, it is important that a check be kept on the shipping and receiving clerks. When the shipping clerk takes charge of the milk-storage room at night, he should check the dayman's inventory of "stocks on hand," which also appears at the bottom of the balance sheet of the plant operations (Form 1 or Form 2). He must account for these stocks by deliveries to the various routes, etc. Form 4 may be used for this purpose after the dayman's inventory is checked. The shipping clerk enters the quantity of goods on hand in the line, "On hand 6 p. m.," in Form 4, as the amount to be accounted for. He next enters the quantity of goods delivered to the various route men, any cash sales, quantity broken or spilled, etc. To these items is added the quantity of goods on hand when he has completed his night's work. This total should equal the quantity on hand the previous evening.

The inventory taken by the shipping clerk should be checked by the dayman when he takes charge of the milk-storage room.

FORM 4.—SHIPPING CLERK'S BALANCE

Date_____19____

	Milk			Cream				But-ter-milk	Skim milk		But-ter	Cheese
	Gallons	Quarts	Pints	Gallons	Quarts	Pints	½ pints	Quarts	Gallons	Quarts	Pounds	Packages
Stocks on hand, 6 p. m.	100	2,000	800	10	2	8	400	100			10	20
Disposal of stocks:												
Delivered to—												
Route 1	10	300	50	5		2	50	20				
Route 2		300	100	5			100	30			5	
Route 3	10	300	100			2	50	30				10
Route 4		410	150				50					
Route 5 (etc.)		300	200			2	50	10				
Cash sales							10					5
Broken or spilled		10					5	1				
Total disposed of	20	1,620	600	10		6	315	91			5	15
On hand, 7 a. m.	80	380	200		2	2	80	8			5	5
Total accounted for	100	2,000	800	10	2	8	395	99			10	20
Over												
Short							5	1				

The man who checks in the routes may be checked by the use of Form 5. He is charged with all goods which he has credited the route men with returning (Form 8), and is credited with the quantity he turns over to other departments, or has on hand at the end of the day. Forms 4 and 5 are valuable for checking both the accuracy

FORM 5.—RECEIVING CLERK'S BALANCE

Date_____19____

	Milk			Cream				But-ter-milk	Skim milk		But-ter	Cheese
	Gallons	Quarts	Pints	Gallons	Quarts	Pints	½ pints	Quarts	Gallons	Quarts	Pounds	Packages
Receipts:												
Received from—												
Route 1	1	10	9			2	10	5			1	
Route 2		50				4	10	8				
Route 3	1	10	10				5	3			1	
Route 4		6	5			2	5	4			2	
Route 5 (etc.)	2	20	8				2					
Total to account for	4	96	32			8	32	20			4	
Deliveries:												
To butter department				2							4	
To byproducts department	31	2										
Other deliveries												
On hand, 6 p. m.								20				
Total accounted for	31	2		2				20			4	
Over												
Short		2		1								

FORM 6.—REPORT FOR MILK COOLER BALANCE

	Milk				Certified milk	Special milk		Buttermilk		Cream				Double cream			
	Gallons	Quarts	Pints	½ pints	Quarts	Quarts	Pints	Gallons	Quarts	Gallons	Quarts	Pints	½ pints	Gallons	Quarts	Pints	½ pints
Receipts:																	
In cooler, 7 a. m.	100	100			2	4		10	10	10					2		10
Received from bottling department		2,000	800						800		4	4	400		1	2	50
Received from other departments	200				20	100		[1] 80		[1] 20							
Converted																	
Total	300	2,100	800		22	104		90	810	30	4	4	400		3	2	60
Disbursements:																	
To pasteurizing department																	
To separator	[1] 100				2	4											
To standardizing cream																	
Converted																	
To retail routes		20	45														
To wholesale routes										5	4		30				
To special delivery routes		20						10		5							
To retail store		50	50						20				20				18
To known losses		5	5						10								
In cooler, 6 p. m.	200	2,000	700		20	100		80	780	20		4	350		3	2	40
Total	300	2,095	800		22	104		90	810	30	4	4	400		3	2	58
Over																	
Short		5															2

[1] 100 gallons of milk were separated into 20 gallons of cream and 80 gallons of skim milk; and 80 gallons of buttermilk were made from this skim milk.

and the honesty of the shipping and receiving clerks. Any considerable shortage indicates that one or more of the route men received more goods than were charged to him or returned less goods than he was credited with.

Milk-Cooler Report

Form 6 may be used as a check on the man who has charge of the milk cooler or milk-storage room during the day. The quantity of goods in the cooler when he takes it over should check with the inventory as reported by the shipping clerk or night man. To this is added all goods transferred to the cooler from the bottling department or other departments during the day and the total of these items is the amount to be accounted for. Under "Disbursements" are entered the quantities of all goods transferred from the cooler to various departments during the day; also all deliveries to the routes. To these items are added the quantities of the various products on hand at the end of the day, and this total should equal the total to be accounted for above. The man in charge of the cooler should not give out any goods except on receipt of the proper order.

Checking the Driver

Each driver should be charged with the goods he takes out on his route and credited for all goods returned. Forms 7 and 8 may be used to check the routes out and in.

When the driver comes in from his route he makes out his order for the following day on Form 7. This quantity is put up the same day by the plant, and given to the driver when he loads the following morning. If changes are made before the driver leaves, these may be noted under "Extras."

Form 7.—Driver's Order

Route___ _____ Date wanted_____19___

	Milk			Cream				Butter-milk	Skim milk	Butter
	Gallons	Quarts	Pints	Gallons	Quarts	Pints	½ pints	Quarts	Gallons	Pounds
Order	15	205	105				15	20		5
Extras	5	5								
Total	20	210	105				15	20		5

On his return from the route the driver enters the quantity of goods returned on the record shown in Form 8. The difference between the totals on Forms 7 and 8 is the amount of net sales for the day or the amount the driver must account for. The driver is also given credit on Form 8 for all bottles returned.

FORM 8.—DRIVER'S RETURN RECORD

Route_____ Date returned_____ 19___

	Milk			Cream				Buttermilk (quarts)	Skim milk (gallons)	Butter (pounds)	Bottles returned		
	Gallons	Quarts	Pints	Gallons	Quarts	Pints	½ pints				Quarts	Pints	½ pints
Returned	10	10	5				5			5	150	150	20
Returned second trip													
Total	10	10	5				5			5	150	150	20

DRIVER'S DAILY REPORT

Form 9 shows a daily report sheet which may be used to account for the goods charged to the driver each day. The quantities of milk, cream, and other goods taken out by the driver, minus the quantities returned, are his net sales which he must account for. The sales to the retail and wholesale trade are figured at the prices charged to the trade, giving the total value of the net sales.

When the ticket system is used the driver accounts for his net sales by filling in the "Sales report" section of Form 9, under which he reports loose tickets turned in, cash sales (wholesale and retail), and the amounts he has charged to any customers who have charge accounts, whether wholesale or retail. The total for these items in the "Sales report" section should equal the total value of the net sales. He accounts for the tickets charged to him under the section headed "Ticket account."

As a rule, the driver will fill in the various items under "Cash account." The total distribution of the cash must of course check with the total amount of cash turned in, and the "Cash sales" in "Distribution of cash received" should check with the "Cash sales" in the "Sales report." On the reverse side of the report sheet he may list his ticket sales and wholesale cash sales. He may also list the amounts collected on account from charge customers. He will also list the amounts charged to wholesale customers, the total of which is the amount of wholesale charges listed under the "Sales report." All totals will be checked by the office checker, who will also check the amount of cash and loose tickets turned in.

Where the majority of the retail customers have charge accounts and a route book is used, the driver would not use the "Ticket account," the "Sales report" section, or the reverse side of the report sheet in Form 9. He lists all cash turned in, as well as loose tickets (when the ticket system is used for some of the customers), and any other credits under "Credits" in Form 9. He accounts for his net load in the vertical space provided directly below the column headed "Total value of net sales." To the total value of the net sales are added the value of any tickets delivered to the driver, and any other charges incurred during the day. From the "Total charges to the driver" are subtracted the "Total credits." To this remainder is added the amount of outstanding charges for the previous day, and the balance is the amount that should be outstanding in the route book.

FORM 9.—DRIVER'S DAILY REPORT [1]

[Front of sheet]

Route No._____ Driver_____ Date_____ 19___

Item	Out first trip	Out second trip	Total out	Returned	Net sales	Retail sales			Wholesale sales			Total value of net sales
						Sales	Price	Value	Sales	Price	Value	
Milk:	*Vol.*	*Vol.*	*Vol.*	*Vol.*	*Vol.*	*Vol.*	*Cents*		*Vol.*	*Cents*		
Gallons			*20*	*10*	*10*				*10*	*55*	*$5.50*	*$5.50*
Quarts			*210*	*10*	*200*	*150*	*18*	*$27.00*	*50*	*16*	*8.00*	*35.00*
Pints			*105*	*5*	*100*	*100*	*10*	*10.00*				*10.00*
½ pints												
Special milk:												
Quarts												
Pints												
Certified milk:												
Quarts												
Pints												
Buttermilk:												
Gallons												
Quarts			*20*		*20*	*20*	*16*	*3.20*				*3.20*
Cream:												
Gallons												
Quarts												
Pints												
½ pints			*15*	*5*	*10*	*10*	*20*	*2.00*				*2.00*
XX cream:												
Gallons												
Quarts												
Pints												
½ pints												
Skim milk:												
Gallons												
Quarts												
Chocolate drink:												
Pints												
½ pints												
Cheese:												
Packages												
Pounds												
Butter: Pounds			*5*	*5*								
Miscellaneous												
Total												*55.70*

CASH ACCOUNT

Cash turned in:	
Cents	
Nickels	
Dimes	
Quarters	*$10.00*
Half dollars	*10.00*
Dollars	
Currency	*15.00*
Checks—	
A	*10.00*
B	
C	*5.00*
D	
E	
F	
G (etc.)	
Total cash	*50.00*
Distribution of cash received: [2]	
Cash received on account. (See other side)	*23.50*
Cash for tickets. (See other side)	*20.00*
Cash sales	*6.50*
Total cash	*50.00*

SALES REPORT [2]

Wholesale charges. (See other side)	*$13.50*
Retail charges (as per route book)	*18.00*
Loose tickets turned in	*17.00*
Cash sales	*6.50*
Total sales	*55.00*
Over	
Short	*70*

TICKET ACCOUNT [2]	
Outstanding tickets charged to driver	$10.00
Tickets delivered to driver today (Book Nos. —)	10.00
Total	20.00
Tickets charged to customers on account	
Tickets sold for cash	20.00
Balance charged to driver	
Total	20.00

CREDIT REPORT [3] — Balance	
Total value of net sales [4]	$55.70
Add any tickets delivered to driver	2.00
Add other charges to driver	
Total charges to driver	57.70
Total credits	54.00
Balance	3.70
Add yesterday's outstanding balance	90.50
Balance outstanding today	94.20

CREDIT REPORT [3] — Credits	
Cash turned in	$50.00
Loose tickets turned in	1.00
Office credits	3.00
Total credits	54.00
Bottles out—number	350
In—do	340
Over—do	
Short—do	10

[Back of sheet]

Name	Address	Page No.	Cash	Charge
Ticket sales			$20.00	
Wholesale sales			5.00	$13.50

Name	Address	Page No.	Amount collected
Collected on account			$23.50

[1] This form can be used at plants where sales are made for cash or tickets and at plants where sales are charged in a route book.

[2] This section is for use at plants where the ticket or cash system is used.

[3] This section is for use at plants where the credit system is principally used.

[4] "Tickets" and "Other charges," if any, are added to the total for "Total value of net sales," given above, to determine the "Total charges to driver."

If the "total credits" is greater than the "total charges to driver," the latter is subtracted from the former, and the difference is subtracted from the "outstanding balance" for the previous day. In that case, the excess of total credits over total charges may be indicated in a different colored ink. The outstanding charges in the route book need not be checked each day, and for the ordinary route will not be checked until the end of the month. Where the driver is likely to make mistakes, however, the route book should be checked more often.

At the end of the month the route book must be checked to see that the outstanding charges in it agree with the "Balance outstanding" indicated on Form 9. If the balance indicated on Form 9 is greater than the total amount as indicated by the route book, the difference is the amount the driver is short.

MONTHLY SUMMARY OF DRIVER'S DAILY REPORTS

At the end of the month all the drivers' daily reports may be recapitulated on the "Monthly summary of drivers' daily reports" (Form 10). Each summary should contain a complete record, for each route, of all sales and credits. The summaries will also show the amount of milk and other goods that each driver is over or short, if the ticket system is used; or they will show the amount that should be outstanding on each route book, if the credit system is used. The totals of all these summaries will contain a complete record of the business done for the month. This form can be modified to suit the particular plant, depending on whether the ticket or the credit system is used.

ROUTE BOOK

At plants where the credit or open-account system is used, it is necessary for the route salesman to have a route book. In this book are listed the names and addresses of all customers on the route, one page being used for each customer. Usually each page will contain the record of one charge customer for one month, but in some cases the page is so arranged that it may contain the records for three to six months. A sample page of a route book similar to that used by many milk plants is given in Form 11. The customers are usually listed in the route book in the order that they are served on the route. The book may be loose leafed, if desired, and in that case any changes in or additions to the list of customers can readily be taken care of in the route book. The route salesman usually "scores" his book daily on his return from his route. In some cases where the customers usually take the same quantity of milk, cream, or other goods from day to day it is not necessary to score the book every day. For accounts on which this practice is followed, the route salesman may enter the quantities delivered to each customer for the first 3 days of the month and make no further entries unless there is a change in the order. Whenever there is a change in the order he will again score such customers for a period of 3 days with no further entries unless the order is again changed. All credits to the customers are entered opposite the proper date either by the route salesman or the office. At the end of the month or week (when weekly bills are rendered) the customers' bills will be made out from the records in the route book.

Form 10.—Summary of Driver's Daily Reports for One Month

Route No. _____ Driver _____ Month of _____

Day	A — Net sales																								B — Value of net sales			C — Sales report							D — Total charges and credits to driver			
	Pasteurized milk				Special milk		Certified milk		Buttermilk		Cream				XX cream				Skim milk		Chocolate drink		Other goods																
	Gallons	Quarts	Pints	½ pints	Quarts	Pints	Quarts	Pints	Gallons	Quarts	Gallons	Quarts	Pints	½ pints	Gallons	Quarts	Pints	½ pints	Gallons	Quarts	Pints	½ pints				Wholesale sales	Retail sales	Total net sales	Wholesale charges	Retail charges	Loose tickets	Cash sales	Over	Short	Cash turned in	Tickets delivered to driver	Total charges to driver[1]	Total credits to driver[2]	Balance outstanding
																									$	$	$	$	$	$	$	$	$	$	$	$	$	$
1																																						
2																																						
3																																						
4																																						
5																																						
6																																						
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14																																						
15																																						
16																																						
30																																						
31																																						
Total																																						

[1] Total net sales plus value of tickets delivered to driver.

[2] All cash turned in.

Note.—Sections A, B, and C are to be used where the ticket system is used, and sections A, B, and D are to be used where the credit system is used with route book.

FORM 11.—SAMPLE PAGE OF ROUTE BOOK [1]

Page No. *45.* Account No. *45.* Date: *Sept.*

Name: *John Smith.* Daily order: *1quart milk, ½ pint cream.*

Address: *50 Maple St.* Directions: *Backdoor.*

	Milk		Cream		Other goods	Charge	Credit
	Quarts	Pints	Pints	½ pints			
Price	*$0.18*			*$0.20*			
Balance from previous month						*$10.00*	
1	*1*			*1*			
2	*1*			*1*			
3	*1*			*1*			
4	*1*			*1*			
5	*1*			*1*			
6	*1*			*1*			
7	*1*			*1*			
8	*1*			*1*			
9	*1*			*1*			
10	*1*			*1*			
11	*1*			*1*			
12	*2*			*1*			
13	*1*			*1*			
14	*2*			*1*			
15	*1*			*1*			*$8.00*
16	*2*			*1*			
17	*1*			*1*			
18	*1*			*1*			
19	*1*			*1*			
20	*1*			*1*			
21	*1*			*1*			
22	*1*			*1*			
23	*1*			*2*			
24	*1*			*2*			
25	*1*			*1*			
26	*1*			*2*			
27	*1*			*1*			
28	*2*			*1*			
29	*2*			*1*			
30	*1*			*1*			
31							
Total	*35*			*33*		*22.90*	*8.00*
Balance forward						*14.90*	

[1] 1 page for each charge customer.

At the end of the month, or more often if necessary, the route book is checked over to determine the total amount that is due from the customers. The total of these unpaid balances is the amount outstanding, and should check with the "Balance outstanding today" at the bottom of Form 9 for that particular date. If the amount outstanding on the book were less than the amount indicated at the bottom of Form 9, this difference would indicate that the driver had failed to turn in some of the payments he had received, or had made some other error, and would be the amount he is short for the month.

These route books are usually of a size that will fit the route salesman's pocket. In some cases, instead of having a column for each product, space is saved by using special symbols to indicate the goods delivered to the customer, so that fewer columns are required. For example, 1, −, and + may be used to denote a quart of milk, a pint of milk, and a half pint of cream, respectively.

NUMBER OF MEN REQUIRED TO OPERATE A MILK PLANT

The number of men required to operate a milk plant depends on the quantity of milk handled, the proportion bottled, and the type and arrangement of the plant and methods of operation. A well-arranged plant of one or two stories requires less labor per 100 gallons handled than a poorly arranged plant or one of several stories (*7*). In plants where most of the milk is bottled, more men will be required to handle a given quantity of milk than in plants where a larger proportion of the milk is put out in bulk.

Table 5 shows the average number of men employed in milk plants of various sizes. There were wide differences in the numbers of men employed at plants of approximately the same size, but the average number shown in the table will give a general idea of the number required to operate a plant of a given capacity. It will be noted that as a rule more milk is handled per man employed at the large plants than at the smaller ones. At large plants the same crew of men is often employed on the same job for the full day, whereas at the small plants it is necessary to shift the men from one job to another. This specialization of labor naturally results in certain economies in operation at the larger plants.

TABLE 5.—*Number of men employed in 194 city milk plants (men inside the plant only)*

Size of plant—quantity handled daily (gallons)	Plants	Average quantity handled daily per plant	Average employees inside plant [1]	Milk handled per plant employee
	Number	*Gallons*	*Number*	*Gallons*
Up to 100	4	63	1. 1	58. 8
101 to 250	19	173	1. 7	100. 0
251 to 500	31	401	2. 8	142. 9
501 to 1,000	34	790	5. 7	142. 9
1,001 to 1,500	16	1, 297	7. 2	166. 6
1,501 to 2,000	11	1, 782	11. 5	166. 6
2,001 to 5,000	21	3, 308	15. 3	216. 0
5,001 to 10,000	34	7, 342	34. 5	213. 0
10,001 to 15,000	9	11, 504	46. 0	249. 0
15,001 to 20,000	8	17, 393	78. 6	221. 0
Over 20,000	7	27, 448	103. 0	267. 0

[1] Including all men whose time was chargeable to the market-milk department. If they were used in other departments also, time was prorated. Clerks and bookkeepers not included.

The number of men employed at 115 plants of various sizes ranged from 2.5 to 6 in small plants of 1,000 gallons capacity or less, up to 59 to 135 in plants handling over 20,000 gallons (table 6). There are also wide variations in the number of gallons handled per plant em-

ployee at plants of similar capacities. While these variations are in part due to such factors as the proportion of bottled and bulk goods put out, they also indicate that some plants are operated more efficiently as to labor used than others of similar capacity. One of the reasons for this is that some plants are arranged more economically than others from the standpoint of labor required (*7*).

TABLE 6.—*Variation in number of gallons of milk handled per plant employee at 115 plants*

Gallons of milk handled per day	Plants	Average quantity of milk handled daily per plant	Employees in plant		Milk handled per plant employee	
			Average	Variation	Average	Variation
	Number	*Gallons*	*Number*	*Number*	*Gallons*	*Gallons*
1,000 or less	4	963	5. 4	2.5 to 6	188	158 to 360
1,001 to 2,000	21	1, 630	7. 4	4 to 14	221	135 to 350
2,001 to 3,000	13	2, 482	9. 7	6 to 16	253	175 to 375
3,001 to 5,000	22	4, 190	19. 6	10 to 30	214	150 to 350
5,001 to 10,000	37	7, 175	32. 8	16 to 52	231	146 to 375
10,001 to 20,000	12	15, 603	65. 8	39 to 90	237	166 to 325
Over 20,000	6	24, 833	96. 0	59 to 135	259	178 to 385
Total	115					

NUMBER OF MEN IN DELIVERY AND OFFICE DEPARTMENTS

The average number of routes, route foremen, and clerical workers at 216 city milk plants, arranged in groups according to plant capacity, are shown in table 7.

On the average the larger plants had fewer routes per 100 gallons handled than the smaller ones. This is due partly to the greater proportion of bulk and wholesale goods handled by the larger plants. The number of routes per route foreman was fairly uniform for plants of all sizes with capacities above 500 gallons of milk daily. At the smaller plants, generally none of the men was specifically designated as route foreman, and in most cases the proprietor looked after the work generally assigned to a route foreman.

The duties of the route foreman or supervisor are varied and only experienced or specially trained men can satisfactorily fill the position. In the first place the foreman must be familiar with each route under his supervision so that he can attend to it in case the regular driver is ill or otherwise unable to do so. Usually he must also be familiar with the credit standing of the customers on the routes under his supervision, and must check up on his drivers to see that the bills are being collected promptly. The drivers will consult with him on the advisability of discontinuing any customers who are delinquent in payment. Another important duty of the route supervisor is to check up on the accuracy as well as the honesty of the driver in keeping the records in the route books. The route supervisor should be suffi-

TABLE 7.—*Number of routes, route foremen, and office workers at 216 pasteurizing plants*

Size of plant—quantity handled daily (gallons)	Plants	Average quantity handled daily	Delivery routes			Office workers			
			Routes per plant	Routes per 100 gallons of milk handled daily	Routes per route foreman	Total clerks		Clerks on route and customer records	
						Clerks per plant	Routes per clerk	Clerks per plant	Routes per clerk
	Number	*Gallons*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Less than 100	4	85	1. 0	1. 2					
101 to 250	18	168	2. 4	1. 4		0. 5	4. 7		
251 to 500	31	390	4. 4	1. 1		. 8	5. 7		
501 to 1,000	35	788	9. 8	1. 2	6. 7	2. 7	3. 7		
1,001 to 2,000	35	1, 505	15. 6	1. 0	[1] 6. 5(33)	3. 6(31)	5. 5(31)	2. 4 (5)	10. 4 (5)
2,001 to 3,000	22	2, 584	27. 9	1. 1	7. 8	5. 1(21)	6. 3(21)	3. 4 (7)	10. 2 (7)
3,001 to 5,000	29	3, 936	36. 5	0. 9	7. 6	6. 9	5. 8	3. 6(10)	12. 0(10)
5,001 to 10,000	32	7, 348	66. 7	0. 9	7. 0(28)	11. 8(25)	6. 3 (25)	6. 8(13)	13. 3(13)
Over 10,000	10	20, 000	143. 4	0. 7	7. 2	32. 6 (6)	5. 1 (6)	16. 8 (4)	10. 2 (4)

[1] Where the number of plants used was smaller than the total, this is indicated by a number in parentheses. For example, the number (33) indicates that the figures on "routes per route foreman" were based on 33 plants out of a total of 35 plants in the 1,001 to 2,000 gallon group.

ciently familiar with each driver's work to judge for himself the necessity of checking up on the outstanding credit accounts in the route book oftener than once a month. In order that he may be thoroughly familiar with each route under his supervision, it is desirable that the supervisor cover each of them with the regular driver at frequent intervals. He must also be able to judge the general efficiency of each man under his supervision, and to advise the men on how to increase their efficiency. He must be on hand each morning to see that all of his men are present to take care of their routes, as he is responsible for the operation of the routes, and in case any men do not come to work he must provide for covering their routes.

At very small plants with only a few routes the proprietor or manager will usually perform the duties generally required of route supervisors at plants operating a large number of routes.

The number of routes per office clerk differed greatly at plants of similar capacities, and there were more office employees at some of the smaller plants than at some of the larger ones. The number of office clerks required depends greatly on the system of accounting used, some of the plants having an excessively large number because of the detailed and rather cumbersome systems used.

WEIGHTS OF MILK AND CREAM

In general, the specific gravity of milk and cream depends on the percentage and relation of the solids, the temperature at which the determinations are made, and the age of the milk. The weight of 1 gallon of water at 68° F. (20° C.) according to the Bureau of Standards, is 8.32162 pounds. Using this figure as the weight of water, and using specific gravities of milk and cream of various percentages, table 8 has been worked out to give the weights per gallon, at a temperature of 68°.

TABLE 8.—*Weight per gallon and specific gravity of milk and cream having various fat contents*

Commodity	Fat content	Specific gravity [1]	Weight per gallon
	Percent		*Pounds*
Water		1. 000	8. 32162
Skim milk	0. 025	1. 037	8. 6295
Milk	3. 5	1. 033	8. 5962
Mixed milk and cream	10. 0	1. 025	8. 5297
Do	15. 0	1. 018	8. 4714
Cream	18. 0	1. 015	8. 4464
Do	20. 0	1. 013	8. 4298
Do	22. 0	1. 011	8. 4132
Do	25. 0	1. 008	8. 3882
Do	28. 0	1. 006	8. 3715
Do	30. 0	1. 004	8. 3549
Do	32. 0	1. 002	8. 3383
Do	35. 0	. 999	8. 3133
Do	38. 0	. 997	8. 2967
Do	40. 0	. 995	8. 2800

[1] Taken from Miscellaneous Publication 138, Refrigeration in the Handling, Processing, and Storing of Milk and Milk Products.

Weights are given at 68° F. because that is the temperature used in determining the specific gravities, being equivalent to 20° C., the temperature generally used for such work. There would be a slight difference for milk at 50° to 60° F., the temperature at which milk is usually received at the plant. For all practical purposes the weight of whole milk may be figured at 8.6 pounds a gallon.

STANDARDIZATION OF MILK AND CREAM

Adjusting the butterfat in milk or cream to a certain desired percentage is known as standardization. The percentage of fat in milk or cream may be lowered by adding a product of lower fat content, such as skim milk, or raised by adding a product of higher fat content.

Standardization is used very generally in preparing cream for market or for use in ice-cream mix. Many State laws and city ordinances prohibit the standardization of milk, however, either directly or indirectly. In most milk laws or regulations, milk is defined as the whole lacteal secretion of one or more healthy cows to which nothing has been added and from which nothing has been taken away. Under a strict interpretation of this definition, changing the percentage of fat in the milk by adding either cream or skim milk would constitute an adulteration in any milk prepared or offered for sale as market milk.

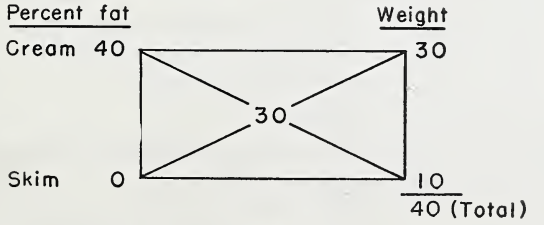
With milk that is to be used for manufacturing dairy products, it is permissible to adjust the fat content to a definite percentage. Before an attempt is made to standardize milk for market use, it would be well to inquire as to the legality of the procedure in the community where the milk is to be sold.

Standardizing Cream

A readily applied formula for use in standardizing milk or cream is the well-known Pearson "rectangle" method.

In the center of a rectangle, place the figure representing the percentage of fat desired in the standardized mixture. At the left-hand corners place the fat percentages of the two substances to be mixed. Then subtract the smaller figures from the larger ones, going diagonally across. Record the differences at the right-hand corners. The number of parts by weight of each ingredient will then be found at the right of the rectangle, horizontally opposite its fat percentage.

To illustrate, suppose one wished to mix skim milk and 40-percent cream to make 30-percent cream, then:



From the diagram it is indicated that 30 parts of 40-percent cream and 10 parts of skim milk will give a mixture containing 30 percent of fat. If a given quantity of 40-percent cream, say 1,500 pounds, is to be

standardized to 30-percent cream with skim milk, the problem would be solved as follows:

$30:10::1,500:X$, where X equals the pounds of skim milk

or

$X=10\times\frac{1,500}{30}$, or 500 pounds of skim milk.

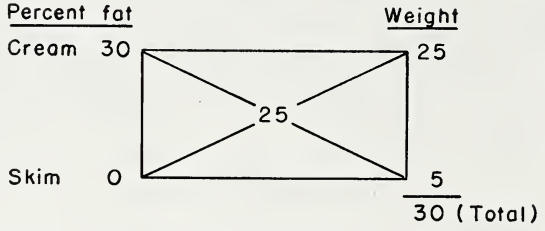
This makes a total quantity of 2,000 pounds (1,500+500). The calculation may be checked as follows:

1,500 pounds of 40-percent cream contains 600 pounds of fat ($1,500\times0.40=600$).

2,000 pounds of 30-percent cream contains 600 pounds of fat ($2,000\times0.30=600$).

TO PRODUCE A DEFINITE QUANTITY OF CREAM OF A CERTAIN FAT CONTENT

Suppose it is desired to produce 2,400 pounds of cream testing 25 percent fat from 30-percent cream and skim milk. Place the desired fat percentage in the center of the rectangle and the fat percentages of the cream and skim milk to be mixed at the two left-hand corners, respectively, and subtract diagonally as before:



Thus, 5 parts of skim milk must be added to 25 parts of 30-percent cream to obtain a mixture of 30 parts of 25-percent cream. To make 2,400 pounds of the 25-percent cream, the problem would be solved as follows:

$30:2,400::25:X$ pounds of 30-percent cream
$30X=60,000$
$X=2,000$ pounds of 30-percent cream

$30:2,400::5:X$ pounds of skim milk
$30X=12,000$
$X=400$ pounds of skim milk

Thus, 2,000 pounds of 30-percent cream and
400 pounds of skim milk make a total of
2,400 pounds of 25-percent cream

This may be checked as follows:

2,000 pounds of 30-percent cream contains 600 pounds of fat ($2,000\times0.30=600$).

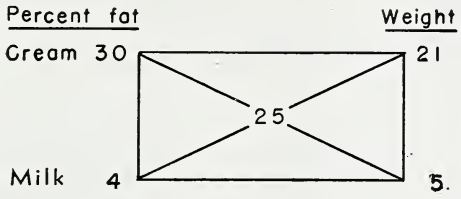
400 pounds of skim milk contains 0 pounds of fat.

Total fat in ingredients 600 pounds.

2,400 pounds of 25-percent cream contains 600 pounds of fat ($2,400\times0.25=600$).

USING WHOLE MILK IN STANDARDIZING CREAM

Where whole milk is to be used in standardizing cream, the same principles will apply. Suppose that 30-percent cream is to be reduced to 25-percent cream by adding milk containing 4 percent of fat, the procedure would be as follows: Place the desired percentage of fat in the center, and the fat percentages of the available cream and milk in the two left-hand corners, respectively, of the diagram, and subtract diagonally as before:



Thus, 21 parts by weight of 30-percent cream and 5 parts of 4-percent milk would be required to make 26 parts of 25-percent cream. If 2,400 pounds of 30-percent cream are to be reduced with 4-percent milk to 25-percent cream, the formula would be as follows:

$21:5::2{,}400:X$ pounds of 4-percent milk

or

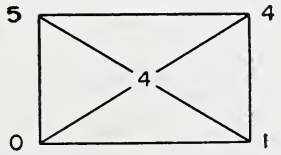
$X=5\times\frac{2{,}400}{21}$, or 571.4 pounds of 4-percent milk required.

This will make a total mixture of 2,971.4 pounds of 25-percent cream. The calculation can be checked as follows:

2,400 pounds of 30-percent cream contains 720 pounds of fat ($2{,}400\times0.30=720$).
571.4 pounds of 4-percent milk contains 22.8 pounds of fat ($571.4\times0.04=22.8$).
Total fat in ingredients: 742.8 pounds.
2,971.4 pounds of 25-percent cream contains 742.8 poundsof fat ($2{,}971.4\times0.25=742.8$).

Standardizing Milk

The same method may be used in standardizing milk to a desired fat content. Suppose it is desired to reduce 5-percent milk to 4-percent milk by adding skim milk:



Thus, 1 part of skim milk added to 4 parts of 5-percent milk will make a mixture of 5 parts of 4-percent milk.

Suppose 2,000 pounds of 5-percent milk is to be reduced with skim milk to 4-percent milk, the formula would be:

$4:1::2{,}000:X$, where X=pounds of skim milk

or

$X=1\times\frac{2{,}000}{4}$, or 500 pounds of skim milk required.

This makes a total of 2,500 pounds (2,000+500) of 4-percent milk. The result can be checked as follows:

2,000 pounds of 5-percent milk contains 100 pounds of fat (2,000 $\times 0.05=100$).

Add 500 pounds of skim milk.

2,500 pounds of 4-percent milk contains 100 pounds of fat ($2{,}500\times 0.04=100$).

As stated before, the practice of standardizing market milk by adding or taking away butterfat is not permitted by many State laws and city ordinances. It should also be noted that when milk is thus standardized the normal percentage of solids-not-fat is changed. When milk is standardized to a lower fat content, as in the above example, the percentage of solids-not-fat is increased; whereas, when milk is standardized to a higher fat content the percentage of solids-not-fat is decreased.

Whenever either milk or cream is standardized, the percentage of fat in the resulting mixture should be determined by the Babcock test as a check on the work.

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